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No. 5

EDWARD JAMES STONE, M.A., F.R.S., Vice-President, in the
Chair.

Arthur Gibbons, Science, Art, and Technical School, Brierley
Hill, Dudley,

was balloted for and duly elected a Fellow of the Society.

The following candidates were proposed as Fellows of the
Society, the names of the proposers from personal knowledge
being appended :—

The Rev. W. H. Addison, 8 West Chapel Street, Mayfair, W.,
(proposed by Edmund J. Spitta) ;

Henry Baynham, Lieutenant, R.N., Captain of H.M.S.
"Wellesley" Training Ship (proposed by David Gill) ;

Humphrey Barker Chamberlin, 1033 Sixteenth Street, Denver,
Colorado, U.S.A. (proposed by H. H. Turner) ;

Otto Jaffe, German Consul, Kin Edar, Strandtown, Belfast,
Ireland (proposed by J. L. E. Dreyer) ;

Charles Henry Johns, M.A., Althorpe House, Waverley Grove,
Hendon, Middlesex (proposed by J. D. McClure) ;

William Grant MacGregor, 18 Coleman Street, E.C. (pro-
posed by R. Grant) ;

Captain R. Reynolds, Lieutenant, R.N.R., U.S.S. "Pretoria,"
Southampton (proposed by D. Forbes) ;

Albert Edward Watson, B.A., F.R.Met.Soc., Whitgift
Grammar School, Croydon (proposed by Charles B.
Neate).

One hundred and twelve presents were announced as having been received since the last ordinary meeting, including, amongst others :—

The Milky Way, drawn at the Earl of Rosse's Observatory, Birr Castle, by Otto Bœddicker, presented by the Earl of Rosse; Comparative Photographic Spectra of the Sun and Metals, and Comparative Photographic Spectra of the High Sun and Low Sun, presented by F. McClean; Photographs of the Spectroscope at the Kenwood Physical Observatory, Chicago, presented by G. E. Hale; Telegraphic Longitudes in Western Australia, presented by the Hydrographer; Recherches sur la Rotation du Soleil, presented by N. C. Dunér; O. Bœddicker, Lunar Radiant Heat, measured at Birr Castle Observatory, presented by the Earl of Rosse.

On the Dynamics of the Earth's Rotation, with respect to the Periodic Variations of Latitude. By Simon Newcomb.

The recent remarkable discovery of Mr. S. C. Chandler, that the axis of rotation of the Earth revolves around the axis of maximum moment of inertia in a period of about 427 days, is worthy of special attention.* At first sight it seems in complete contradiction to the principles of dynamics, which show that the ratio of the time of such a rotation to that of the Earth's revolution should be equal to the ratio of the polar moment of inertia of the Earth to the difference between the equatorial and the polar moments. Representing these moments by A and C, it is well known that the theory of rotation of a rigid body gives the equation

$$\tau = \frac{A}{C - A},$$

τ being the period of rotation of the pole in sidereal days.

Now the ratio in question is given with an error not exceeding a few hundredths of its total amount by the magnitude of the precession and nutation. The value found by Oppolzer is

$\frac{1}{305}$, giving the time of rotation as 305 days.

This result has long been known, and several attempts have been made to determine the distance between the two axes, especially at Pulkova and Washington. A series of observations was made with the Washington Prime Vertical Transit during the years 1862-1867, including six complete periods of the inequality. Thus the determination of the coefficient and zero of the argument is completely independent of all sources of error having an annual or diurnal period. Such errors are

* *Astronomical Journal*, Numbers 248, 249.

liable to affect the determination unless it is continued over this period.

A preliminary discussion of the observations, which was made at the request of Sir William Thomson, and published by him, gave a coefficient of $0''\cdot05$ for the inequality. A more complete discussion, undertaken quite recently, reduces the coefficient to $0''\cdot03$, corresponding to a distance of three feet between the two axes. This result was quite within the limits of errors of observation, and seemed to show that there was no appreciable difference between the two axes. This result was in complete accordance with the conclusions reached from the Poulkova observations, and seemed to show, beyond doubt, that there could be no inequality of the kind looked for.

Mr. Chandler's discovery gives rise to the question whether there can be any defect in the theory which assigns 306 days as the time of rotation. The object of this paper is to point out that there is such a defect—namely, the failure to take account of the elasticity of the Earth itself, and of the mobility of the ocean.

The mathematical theory of the rotation of a solid body, on which the conclusions hitherto received have been based, presupposes that the body is absolutely rigid. As the Earth and ocean combined are not absolutely rigid, we have to inquire whether their flexibility appreciably affects the conclusions. That it does can be shown very simply from the following consideration:—

Imagine the Earth to be a homogeneous spheroid, entirely covered by an ocean of the same density with itself. It is then evident that, if the whole mass be set in uniform rotation around any axis whatever, the ocean will assume the form of an oblate ellipsoid of revolution, whose smaller axis coincides with that of rotation. Hence, the axes of rotation and of figure will be in perfect coincidence under all circumstances.

To apply a similar reasoning to the case of the Earth, imagine that the axis of rotation is displaced by $0''\cdot20$ from that of greatest moment of inertia, which I shall call the axis of figure. Then, with an ocean of the same density as the Earth, its equator would be displaced by the same amount. The ocean level would change in middle latitudes by about one inch at the maximum. But this change would have for its effect a corresponding change in the axis of figure. As the ocean covers only three-fourths of the Earth, the axis would be displaced by three-fourths of the distance between the two axes, were ocean and Earth of equal density. But, as the density of the Earth is some five times as great, the actual change would be only one-fifth of this. It would even be less than one-fifth, because the displacement of the ocean equator would be resisted by the attraction of the Earth itself. The exact amount of this resistance cannot be accurately given, but I think the displacement would thereby be

reduced to one-half. I therefore think that one-fourteenth would be an approximate estimate of the displacement of the axis of figure, in consequence of the movement of the ocean. As Mr. Chandler's period requires a displacement of two-sevenths, the ocean displacement only accounts for one-fourth of the difference.

The remainder is to be attributed to the elasticity of the Earth itself. It is evident that the flexure caused by the non-coincidence of the two axes tends to distort the Earth into a spheroid of the same form as that which the ocean assumes, and thus to bring the two axes together.

We have now to show how this deformation of the Earth changes the time of revolution. Let us imagine ourselves to be looking down upon the North Pole, and let P be the actual mean pole of the Earth when the two axes are in coincidence, and R the end of the axis of rotation. Then, in consequence of the rotation around R , the actual pole will be displaced to a certain point, P' . Now, the law of rotation of R is such that it constantly moves around the instantaneous position of P' in a period of 305 days, irrespective of the instantaneous motion of P' itself. In other words, the angular motion of R at each moment is that which it would have if P' had remained at rest. Hence, the angular motion as seen from P is less than that from P' , in the ratio of $P'R : PR$.

But, as R rotates, P' continually changes its position and rotates also, remaining on the straight line PR . Thus the time of revolution of R around P is increased in the same ratio.

We may next inquire what degree of rigidity the Earth must have in order that the total displacement of the axis of figure produced by the change in the centrifugal force may be two-sevenths that of the displacement of the axis of rotation; in other words, that the ratio $P'R : PR$ may be $5 : 7$. A rigorous treatment of the problem is scarcely possible, as the rigidity probably varies from the surface inward; I shall therefore only attempt a rough estimate, founded on certain conclusions as to the deformation of a rotating spheroid reached in Thomson and Tait's *Natural Philosophy*. To proceed in the simplest way, I shall assume the earth to have the rigidity of steel, and inquire to what displacement the axis of figure would be subject, in consequence of the centrifugal force arising from a rotation around an axis differing from the normal axis of figure.

Conceive a solid sphere, of the same size and general constitution as the Earth, to be set in rotation like the Earth. Let ϵ' be the ellipticity induced in it by the rotation, and let ϵ be the actual ellipticity of the Earth. We shall then have a superposition of two ellipticities, the one ϵ , such that P is the pole of figure; the other, ϵ' such that R is the pole of figure. P' being the pole arising from the combined ellipticities, I assume that we have the proportion

$$PP' : \epsilon' = P'R : \epsilon.$$

To find the value of ϵ' I start from the conclusion of Thomson

and Tait (§837), that a ball of steel of any radius rotating with an equatorial velocity of 10,000 centimetres per second will be flattened to an ellipticity of $\frac{1}{7220}$. The Earth's equatorial velocity is 4.65 times this. Its density is less than that of steel: the density which we should assume is not the actual mean density but a mean in which greater weight is given to the superficial portions, because these have the greatest centrifugal force. Probably the actual mean to be adopted is 0.6 of the density of steel. We have, therefore, neglecting the effect of gravitation,

$$\epsilon'_0 = \frac{0.6 \times 4.65^2}{7220} = \frac{1}{557}.$$

But the deformation of the Earth is resisted by the gravitation of its parts. By a theorem given by Thomson and Tait, we should have, taking this effect into account—

$$\frac{1}{\epsilon'} = \frac{1}{\epsilon'_0} + \frac{1}{\epsilon} = 557 + 292 = 849.$$

Hence we have

$$\epsilon' = \frac{1}{849}.$$

Hence, considering only the solid Earth,

$$PP' : P'R = 292 : 849.$$

We have already concluded that the motion of the ocean will shift P' one-fourteenth of the way from P' to R. Hence, finally,

$$PP' : P'R = 353 : 788$$

$$PR : P'R = 1142 : 788.$$

$$\text{Time of revolution of pole} = 443 \text{ days}$$

$$\text{Period for a rigid earth} = 306 \text{ ,,}$$

$$\text{Computed increase of period} = 137 \text{ ,,}$$

$$\text{Observed increase of period} = 121 \text{ ,,}$$

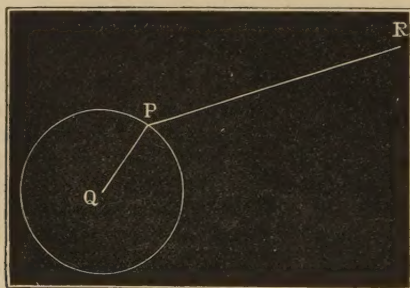
The conclusion is that the Earth yields slightly less to the centrifugal force than it would if it had the rigidity of steel, and that it is consequently slightly more rigid than steel.

We have next to consider the effect of viscosity of the earth. Those geologists who have given special attention to the subject regard it as well established that the Earth yields under the weight of deposits as if it were a thin crust floating upon a liquid interior, and must therefore be a viscous solid, if a solid at all. The effect of viscosity is that the normal pole P of the Earth would be in slow but continuous motion towards the revolving pole R. Both P and R would then describe logarithmic spirals, so related that the tangent to the inner spiral at the position of P at any moment would pass through the position of R at that moment, and cut the R spiral normally. Thus the line PR would diminish from century to century by equal

fractions of its amount in equal times. Thus the poles would eventually appear to meet, unless separated from time to time by the action of causes changing one or both of them.

Since the position of the pole of figure of the Earth may be supposed to have been originally determined by the rotation itself, and continually to approach the pole of rotation if it were very slightly separated from it, the presumption would appear to be that the two poles would now be in apparent coincidence, in the absence of disturbing causes. Moreover, the evidence of the most accurate observations hitherto made with Prime Vertical Transits seems to show that the separation of the two poles at the epochs 1842 and 1864 could scarcely have exceeded the tenth of a second. But observations made with probably equal exactness at the present time seem to show, according to Mr. Chandler, a separation of $0''.3$. It would seem, therefore, accepting these provisional numerical results, that some disturbing cause has acted. A *vera causa* was pointed out some years ago by Sir William Thomson, in the motions of the winds and oceans, and especially in changes in the polar ice-cap. In order to have its greatest effect such a movement of matter must occur in the middle latitudes; a change in the polar ice-cap would be the less appreciable in its effect the nearer it occurred to the pole. A heavy snow-fall over the whole of Northern Asia, unaccompanied by a corresponding fall on the American continent, would undoubtedly cause a slight displacement; but I doubt whether the greatest effect of this kind could amount to $0''.05$.

But we have also to consider the effect of an annually repeated disturbance of this kind. Mr. Chandler's period is such that the pole of rotation makes six revolutions in seven years. Hence, during one-half the period of seven years, the effect of an annually repeated cause will be cumulative. In a recent volume of the *Bulletin Astronomique*, Mr. Radau has investigated the effect of an annual periodic change in the position of the Earth's axis of figure, and shown that it will be multiplied three times, in consequence of this cumulative effect. But his analysis rests on the hypothesis of a 306-day period. It is worth while to show how such an annual cause would act when we adopt Mr. Chandler's period.



Let Q be the mean position of the pole of figure of the Earth, and let us assume that the actual pole P revolves around it in a radius a , and in a period of one year. Let R be the position of the pole of rotation at any time. Then, at each moment, R is revolving around the fixed position P with a uniform motion, which, if continued, would cause it to complete a revolution in 427 days. Let us put

n , the mean motion of the radius PQ ;

μ , the mean motion of R around the position of P ;

x, y , the rectangular co-ordinates of R referred to Q as an origin.

The law of rotation then gives the equations

$$\frac{dx}{dt} = -\mu y + a\mu \sin(nt + c)$$

$$\frac{dy}{dt} = \mu x - a\mu \cos(nt + c).$$

The integration of these equations gives

$$x = a \cos \mu t - \beta \sin \mu t - \frac{a\mu}{n - \mu} \cos(nt + c)$$

$$y = a \sin \mu t + \beta \cos \mu t - \frac{a\mu}{n - \mu} \sin(nt + c),$$

a and β being arbitrary constants.

Substituting for μ and n their numerical values, we have, approximately,

$$x = a \cos \mu t - \beta \sin \mu t + 6a \cos(nt + c)$$

$$y = a \sin \mu t + \beta \cos \mu t + 6a \sin(nt + c).$$

Such a rotation as we have supposed, around a circle of $0''.05$ in radius, would suffice to produce anomalies as large as those actually observed.

If the winters in Siberia and in North America occurred at opposite seasons, we should have no difficulty in accepting the sufficiency of annual falls of snow to account for the anomaly. But, under the actual circumstances, we must await the results of further investigations into the whole subject.

On the Displacement of the Apparent Radiant Points of Meteor-Showers due to the Attraction, Rotation, and Orbital Motion of the Earth. By Joseph Kleiber.

The question of the shifting or immobility of radiant points of meteoric showers has been lately discussed with warmth from the point of view of several observers, in the pages of these *Notices* and elsewhere. As no theoretical investigation into this subject has yet appeared, I trust that the following lines

may be of some interest, and may help to elucidate this question which has been the subject of so much controversy.

There are three principal causes of the displacement of the apparent radiant of a meteor shower. These are—

1. The *attraction* of the Earth.
2. The *rotation* of the Earth.
3. The *orbital motion* of the Earth.

I shall consider these causes separately in the order here indicated, and trace the theoretical curves described by a radiant under the separate influence of each of them, and of the three conjointly, and shall illustrate the theory by applying it to two characteristic examples.

i. The *Perseid swarm*, which is the one chiefly concerned in the discussion alluded to above, and which will furnish an especially good illustration of the *third* of the causes just mentioned;

ii. The *Andromedid swarm*, whose position is especially adapted for illustrating the displacement of a radiant due to the *first* of these causes, and to show how a diffused radiation may be the consequence of the action of this first cause alone.

I. *The Attraction of the Earth.*

The displacement of a meteoric radiant due to the attraction of our planet on every meteor of the shower consists in the fact that the meteors of a swarm describe hyperbolas about the Earth's centre as a focus, instead of describing straight lines, and that the apparent direction of a meteor's path is determined by the direction of the tangent to this hyperbola at the point where it meets the Earth's atmosphere, instead of being determined by the direction of its asymptote—the latter representing the undisturbed path of the meteor. The amount of this displacement, *i.e.* the angle between the tangent to the meteor's visible track and the asymptote, or the direction of its undisturbed motions depends—

- (i.) On the relative velocity of the meteors with respect to the Earth; and
- (ii.) On the angle between the direction of the path of the meteors, and their radius vector from the Earth's centre, *i.e.* the zenith distance of their radiant.

Formulae for the computation of the value of this displacement were given more than twenty years ago by G. V. Schiaparelli in his classic work on shooting stars, and they need not be repeated here. Only the final result will be given and applied to numerical examples.

The attraction of the earth *diminishes* the zenith distance of every radiant, leaving its azimuth unchanged.

Let w be the undisturbed relative velocity of the meteors of a particular shower, and w_1 their relative velocity accelerated by the attraction of the Earth. Then the equation of *vis viva* gives

$$w_1^2 = w^2 + 2gr.$$

Let Δz be the difference between the disturbed and undisturbed zenith distance of the radiant, and

$$\Delta z_0 \text{ the value of } \Delta z \text{ when } z = 90^\circ,$$

i.e. when the radiant is on the horizon; then Schiaparelli finds—

$$\tan \frac{1}{2} \Delta z_0 = \frac{w_1 - w}{w_1 + w},$$

and also

$$\tan \frac{1}{2} \Delta z = \tan \frac{1}{2} \Delta z_0 \tan \frac{1}{2} z.$$

These are the formulæ we shall use in our *second* example. In the particular cases when Δz_0 is small, the following approximate formulæ are more convenient:—

$$\Delta z = c \tan \frac{1}{2} z$$

$$c = \frac{a}{w^2} \quad (\log a = 2.941).$$

The usual astronomical units being used, the formulæ give c and Δz in degrees, and Δz having been computed, $\Delta \alpha$ and $\Delta \delta$ may be found from known formulæ.

Example 1. Perseids.—Among the many different positions given for the radiant of this swarm, it is difficult to make a choice which will not be to a great extent arbitrary. Again, as all these radiants are deduced from observations uncorrected for any of the three causes here considered, it would be inconsistent to start from values which will be shown to differ sensibly from those that would have been found if appropriate methods were used in the determination of radiants. I prefer, therefore, to take the radiant of the comet 1862 iii. in its node, and to apply to it the corrections here indicated.

The orbit of the comet does not geometrically intersect that of the Earth; but we may dispose of the value of its period of revolution or major axis, so as to give it a real point of intersection. Thus, if we take the following elements of this comet:—

$$\pi = 289^\circ 78$$

$$\Omega = 137.45$$

$$i = 113.57$$

$$\phi = 74^\circ 01,$$

we shall find for the co-ordinates of the radiant point

$$\alpha = 43^{\circ}58'$$

$$\delta = 57^{\circ}08'.$$

These values correspond to the epoch when $\odot = 137^{\circ}45' (= \infty)$, i.e. approximately to August 9.5 (Greenwich time). The periodic time of the comet, or rather of the meteoric swarm moving in the comet's orbit, is found to be 122.9 years, when the orbit of this swarm and that of the Earth really intersect in the node of the former.

From this position of the undisturbed apparent radiant I find that the *elongation of the radiant from the Earth's apex*, i.e. the angle between the direction of the motion of the Earth and the direction of the apparent radiant, is

$$\epsilon = 39^{\circ}90',$$

and hence the *relative velocity* of the comet in its node is found to be 2.02 times that of the Earth at the same moment, or, in usual astronomical units,

$$\log w = 8.5354,$$

and the abridged formulæ of this section give

$$c = 1^{\circ}03'.$$

This is the largest displacement which could be produced on the radiant of the *Perseids* by the attraction of the Earth, if the radiant ever reached the horizon; but this radiant never sets at Greenwich (for which place we are computing all our results), and thus the so-called *zenith-attraction* never attains this value.

In order to give a clear idea of the influence of this disturbing cause on the positions of the radiant at different hours of the night, I have computed the corrections $\Delta\alpha$, $\Delta\delta$, to be applied to its co-ordinates for every three hours, beginning at the moment when the hour angle is 0, and ending twenty-four hours later.

The formulæ for the computation of these corrections are

$$\Delta\alpha \cos \delta = -\Delta z \sin Q$$

$$\Delta\delta = -\Delta z \cos Q,$$

Q being the "parallactic angle."

By means of these formulæ and the figures given above, I find the following corrections:—

TABLE I.

<i>t</i> h	<i>z</i>	<i>Q</i>	Δz	$\Delta \alpha$	$\Delta \delta$	<i>T</i> h
0	5°6	180°0	-0°05	0°00	-0°05	6
3	26°4	82°7	-0°24	+0°44	+0°03	9
6	48°9	55°7	-0°47	+0°71	+0°26	12
9	65°3	29°0	-0°66	+0°59	+0°58	15
12	71°4	0°0	-0°74	0°00	+0°74	18
15	65°3	331°0	-0°66	-0°59	+0°58	21
18	48°9	304°3	-0°47	-0°71	+0°26	0
21	26°4	277°3	-0°24	-0°44	+0°03	3
	5°6	180°0	-0°05	0°00	-0°05	6

The last column gives the approximate mean time corresponding to the values indicated in the table.



Fig. 1.

Fig. 1 illustrates this table. The attraction curve is an oval described by the radiant in twenty-four hours. The figures along the curve denote the mean Greenwich time of the corresponding position as given in the last column of the table above. We see from the diagram that the undisturbed position of the radiant differs not only from its real position (so far as it is affected by the attraction of the Earth alone) at any particular moment, but also from the mean position of the disturbed radiant during a whole period, the radiant lying very eccentrically in the oval described by its successive disturbed positions.

Example 2. Andromedids.—Very different is the case of the *Andromedid* swarm. The meteors of the *Perseid* shower possess a large relative velocity, and the disturbing action of the Earth's attraction on the position of its radiant is accordingly comparatively small. The relative velocity of the *Andromedids* is, on the contrary, of the very smallest, and the disturbing action due to the Earth's attraction on them is consequently enormous.

I take here again, as in the former case, the cometary radiant to start from. The elements of the comet Biela being

$$\pi = 108^{\circ}97$$

$$\varpi = 245^{\circ}97$$

$$i = 12^{\circ}57$$

$$\phi = 49^{\circ}03.$$

I find for the position of the radiant in the node of the cometary orbit the co-ordinates

$$\alpha = 23^{\circ}27$$

$$\delta = 43^{\circ}12.$$

The epoch of the swarm is approximately November 27.5 (corresponding to $\odot = 245^{\circ}97$), and the periodic time of the meteoric swarm is found to be 6.72 years, when the orbit of this swarm and that of the Earth intersect in a real point.

From these data the elongation of the radiant from the Earth's apex is found to be

$$\epsilon = 113^{\circ}73,$$

and hence the relative velocity of the swarm in its node is equal to 0.53 of the Earth's orbital velocity at the same time; in astronomical units

$$\log w = 7.9592$$

This gives for Δz_0 the enormous value $11^{\circ}70$! But the radiant of this swarm also never sets in the latitude of Greenwich. In the same way as in the former example, I find the following values of z , Q , Δz , $\Delta \alpha$ and $\Delta \delta$ for every three hours of the hour angle t from $t=0$ to $t=24^h$.

TABLE II.

t h	z	Q	Δz	$\Delta \alpha$	$\Delta \delta$	T h
0	$8^{\circ}4$	$0^{\circ}0$	$-0^{\circ}86$	$0^{\circ}00$	$+0^{\circ}86$	15
3	$31^{\circ}1$	$58^{\circ}4$	$-3^{\circ}25$	$+3^{\circ}80$	$+1^{\circ}71$	18
6	$57^{\circ}7$	$47^{\circ}4$	$-6^{\circ}45$	$+6^{\circ}65$	$+4^{\circ}36$	21
9	$76^{\circ}7$	$26^{\circ}8$	$-9^{\circ}28$	$+5^{\circ}72$	$+8^{\circ}26$	0
12	$85^{\circ}4$	$0^{\circ}0$	$-10^{\circ}80$	$0^{\circ}00$	$+10^{\circ}80$	3
15	$76^{\circ}7$	$26^{\circ}8$	$-9^{\circ}28$	$-5^{\circ}72$	$+8^{\circ}26$	6
18	$57^{\circ}7$	$47^{\circ}4$	$-6^{\circ}45$	$-6^{\circ}65$	$+4^{\circ}36$	9
21	$31^{\circ}1$	$58^{\circ}4$	$-3^{\circ}25$	$-3^{\circ}80$	$+1^{\circ}71$	12
24	$8^{\circ}4$	$0^{\circ}0$	$-0^{\circ}86$	$0^{\circ}00$	$+0^{\circ}86$	15

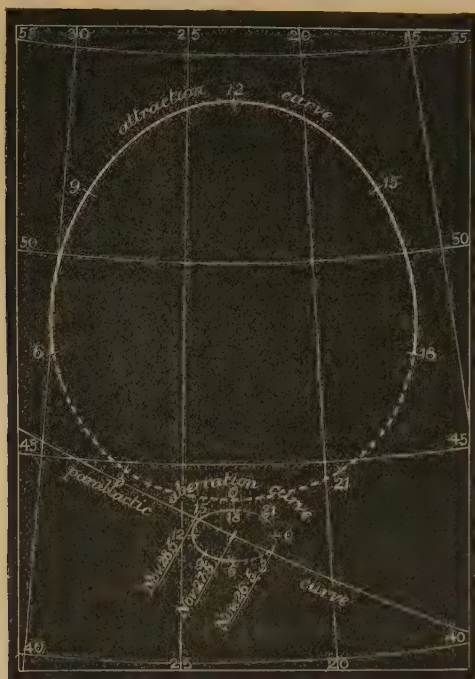


Fig. 2.

Fig. 2 illustrates this table. The attraction curve is here a very large oval, the undisturbed radiant being not inside but outside the curve, and at a distance of about six degrees from its central point.

II. The Rotation of the Earth.

1. *Perseids*.—This cause produces a small aberration of the radiant, never amounting to more than one degree in arc, at the latitude of Greenwich. The displacements $\Delta\alpha$, $\Delta\delta$ may be computed by means of the following formulæ, analogous to those used in the computation of the aberration of light.*

$$\Delta\alpha = -0.52 \cos t$$

$$\Delta\delta = -0.23 \sin t$$

whence I find the following table of corrections.

* These formulæ were first indicated by R. Lehman-Filhés in his *Inaugural-Dissertation: Zur Theorie der Sternschnuppen*, Berlin, 1878.

TABLE III.

t h	$\Delta\alpha$	$\Delta\delta$	T h
0	$-0^{\circ}52$	$0^{\circ}00$	6
3	$-0^{\circ}37$	$-0^{\circ}17$	9
6	$0^{\circ}00$	$-0^{\circ}23$	12
9	$+0^{\circ}37$	$-0^{\circ}17$	15
12	$+0^{\circ}52$	$0^{\circ}00$	18
15	$+0^{\circ}37$	$+0^{\circ}17$	21
18	$0^{\circ}00$	$+0^{\circ}23$	0
21	$-0^{\circ}37$	$+0^{\circ}17$	3
24	$-0^{\circ}52$	$0^{\circ}00$	6

This table is illustrated in Fig. 1 by the *aberration curve*—a small ellipse described by the radiant about its mean position.

2. *Andromedids*.—In the same way I find for the November shower

$$\Delta\alpha = -1^{\circ}45 \cos t$$

$$\Delta\delta = -0^{\circ}72 \sin t$$

which gives the following table of corrections:—

TABLE IV.

t h	$\Delta\alpha$	$\Delta\delta$	T h
0	$-1^{\circ}45$	$0^{\circ}00$	15
3	$-1^{\circ}03$	$-0^{\circ}51$	18
6	$0^{\circ}00$	$-0^{\circ}72$	21
9	$+1^{\circ}03$	$-0^{\circ}51$	0
12	$+1^{\circ}45$	$0^{\circ}00$	3
15	$+1^{\circ}03$	$+0^{\circ}51$	6
18	$0^{\circ}00$	$+0^{\circ}72$	9
21	$-1^{\circ}03$	$+0^{\circ}51$	12
24	$-1^{\circ}45$	$0^{\circ}00$	15

The small *aberration curve* in Fig. 2 illustrates the displacement of this radiant due to the rotation of the Earth.

III. The Orbital Motion of the Earth.

The orbital motion of the Earth plays a very important part in determining the position of the apparent radiant, provided that the observations of meteors belonging to the same shower extend over a long period of time. In fact, the apparent radiant is given by the direction of the diagonal constructed on the absolute velocities of the Earth and meteors respectively, but the directions of the tangents to the orbits described by the Earth and a meteoric swarm change every moment, and are widely different in different points of space; thus, if the meteor shower be very

extended, so that its meteors are seen during several successive days, or even weeks, the position of its apparent radiant must be different for each day. We shall now proceed to the computation of this most important part of the apparent displacement of radiants.

Two views may be taken *à priori* of the subject. First, a meteor shower may constitute a ring (or part of a ring) having a definite orbit in the solar system. In this case the elements ι , $\pi - \Omega$ (and ϕ if the orbit is an ellipse) are constant for all parts of the ring. Or, secondly, the meteor stream may be considered as the result of the disintegration of an agglomeration of independent cosmical particles which enter the solar system from external interstellar space*; in this case the elements of every portion of the stream must be different, whereas the heliocentric position of the aphelion or perihelion of the orbit is the same for every portion.

The first supposition—which will prove to be the true one at least in the case of the *Perseids*—leads to a very simple rule for the displacement of the apparent radiant of a meteoric ring, viz. :—

The latitude of the radiant remains constant, its longitude increases (approximately) proportionally to time.—In other words, if A be the longitude of the Earth's apex, then the quantities $l - A$, C are constant for every radiant—with a very small correction due to the eccentricity of the Earth's orbit; i.e. the radiant moves uniformly in a circle parallel to the ecliptic. The proof of this rule is very simple. It is known that the elements ι and $\pi - \Omega$ of a parabolic meteoric orbit are completely determined if the values of $l - A$ and C are given; and *vice versa*, if ι and $\pi - \Omega$ are given and have constant values, the co-ordinates $l - A$, C must have constant values too. For elliptic orbits $l - A$, C and ϕ completely determine ι and $\pi - \Omega$; and conversely, ι , $\pi - \Omega$ and ϕ completely determine $l - A$ and C . Thus, in every case the radiant of a meteor-shower will move according to the rule given above.

This rule forms an excellent test both for the theory and for the observations. If a series of radiant points be given, belonging to the same meteoric shower, and observed during a long period of time, we have only to express their positions in longitude and latitude instead of in right ascension and declination, and to subtract from the longitude of each radiant the longitude of the Earth's apex at the same moment; then all the radiants must coalesce in one point.

Of course we cannot expect a perfect coincidence of all radiants after this operation; the inevitable errors of observation, the inaccurate method used in determining the position of the radiant points from observed meteor-paths, the neglected corrections due to the attraction and rotation of the Earth; all

* This view has been taken by Mr. Hoek in a paper published in the *Monthly Notices*.

these causes agree in displacing the observed radiant point from its true position, and the combined effect of these causes may, even in the more favourable case of a swarm like the *Perseids*, easily amount to several degrees.

The observations of Mr. Denning on the *Perseid* swarm extend over a period of almost six weeks (July 8–August 16). During this time the radiant describes, according to Mr. Denning, an arc extending *fifty-seven degrees* in right ascension and *ten degrees* in declination. The identification of points so distant from one another as one and the same radiant has been objected to; doubts have been expressed as to the possibility of a real connection between these different radiations, and more cogent reasons than the mere resemblance in the physical appearance of their meteors have been asked for.

Now if we perform on all the forty-nine radiants indicated in Mr. Denning's catalogue as belonging to the *Perseid* shower, the operations explained above, we obtain a result which supports Mr. Denning's (and our) view on these radiants even better than could be expected.

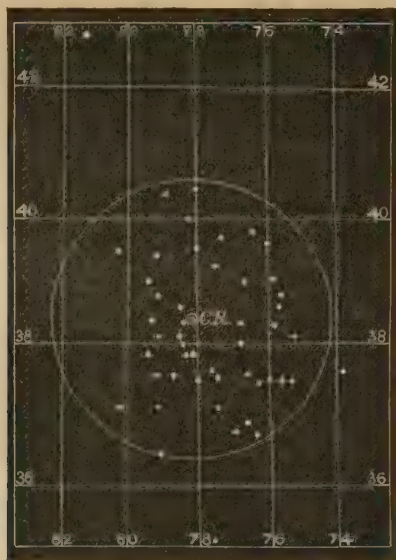


Fig. 3.

Fig. 3 shows the positions of all these radiants after the reduction,* *i.e.* after the parallactic correction has been applied

* I do not here give the details of the calculation as they are incorporated in the "Catalogue of Meteoric Orbits" appended to my Treatise *On the Determination of Orbits of Meteor-Showers*, St. Petersburg, 1891 (in Russian, with an abstract in English), on pp. 279–291. The ecliptical co-ordinates l, b of the radiants are given there, together with the differences $\odot^1 - l$, where $\odot^1 = A - 90^\circ$. The fig. gives the positions of these points in the co-ordinates $\odot^1 - l, b$.

to them, together with the position of the cometary radiant. It will be seen that out of the forty-nine radiants *forty-six* lie within a circle described about the cometary radiant with a radius of two degrees, three only being outside this circle, and of these the two remotest at a distance of $4\frac{1}{2}^\circ$ and $3\frac{1}{2}^\circ$ respectively. These two last are precisely the first and last of the series; the first corresponding to July 8 and deduced from *five* meteor tracks only, and the last, on August 16, deduced from eight observations, and I hope that fresh data will bring them still nearer to the cometary radiant.*

It remains now to consider the real motion of a meteoric radiant as it results from the combined action of the three disturbing causes. The *parallactic curve* is drawn in Figs. 1 and 2, together with the two other curves described above, and the position of the radiant on it on three consecutive days is indicated. Combining the displacements due to the attraction and aberration of the radiant with its parallactic motion, I find, for the *Perseids* and *Andromedids*, the following positions on three consecutive days, and for every three hours of each day :—

TABLE V.

(Perseids) $\alpha_0 = 43^\circ 58'$ $\delta_0 = 57^\circ 08'$

	T	$\Delta\alpha, \Delta\alpha_1 + \Delta\alpha_2$ parallactic	$\Sigma\Delta\alpha$	$\Delta\delta, \Delta\delta_1 + \Delta\delta_2$	$\Sigma\Delta\delta$	Ultimate. α	δ
Aug. 8	h						
	0	$-2^\circ 01' + 0^\circ 71'$	$-1^\circ 30'$	$-0^\circ 42' + 0^\circ 03'$	$-0^\circ 39'$	$42^\circ 28'$	$56^\circ 69'$
	3	$-1^\circ 85' + 0^\circ 95'$	$-0^\circ 90'$	$-0^\circ 39' + 0^\circ 41'$	$+0^\circ 02'$	68	$57^\circ 10'$
	6	$-1^\circ 68' + 0^\circ 52'$	$-1^\circ 16'$	$-0^\circ 35' + 0^\circ 74'$	$+0^\circ 39'$	42	47
	9	$-1^\circ 51' - 0^\circ 23'$	$-1^\circ 74'$	$-0^\circ 32' + 0^\circ 75'$	$+0^\circ 43'$	$41^\circ 84'$	51
	12	$-1^\circ 34' - 0^\circ 71'$	$-2^\circ 05'$	$-0^\circ 28' + 0^\circ 49'$	$+0^\circ 21'$	53	29
	15	$-1^\circ 17' - 0^\circ 80'$	$-1^\circ 97'$	$-0^\circ 24' + 0^\circ 20'$	$-0^\circ 04'$	61	04
	18	$-1^\circ 01' - 0^\circ 52'$	$-1^\circ 53'$	$-0^\circ 21' - 0^\circ 05'$	$-0^\circ 26'$	$42^\circ 05'$	$56^\circ 82'$
	21	$-0^\circ 84' + 0^\circ 08'$	$-0^\circ 76'$	$-0^\circ 18' - 0^\circ 14'$	$-0^\circ 32'$	82	76
Aug. 9	0	$-0^\circ 67' + 0^\circ 71'$	$+0^\circ 04'$	$-0^\circ 14' + 0^\circ 03'$	$-0^\circ 11'$	$43^\circ 62'$	97
	3	$-0^\circ 51' + 0^\circ 95'$	$+0^\circ 44'$	$-0^\circ 11' + 0^\circ 41'$	$+0^\circ 30'$	$44^\circ 02'$	$57^\circ 38'$
	6	$-0^\circ 34' + 0^\circ 52'$	$+0^\circ 18'$	$-0^\circ 07' + 0^\circ 74'$	$+0^\circ 67'$	$43^\circ 76'$	75
	9	$-0^\circ 17' - 0^\circ 23'$	$-0^\circ 40'$	$-0^\circ 04' + 0^\circ 75'$	$+0^\circ 71'$	18	79
	12	$0^\circ 00' - 0^\circ 71'$	$-0^\circ 71'$	$0^\circ 00' + 0^\circ 49'$	$+0^\circ 49'$	$42^\circ 87'$	57
	15	$+0^\circ 17' - 0^\circ 80'$	$-0^\circ 63'$	$+0^\circ 04' + 0^\circ 20'$	$+0^\circ 24'$	95	32
	18	$+0^\circ 34' - 0^\circ 52'$	$-0^\circ 18'$	$+0^\circ 07' - 0^\circ 05'$	$+0^\circ 02'$	$43^\circ 40'$	10
	21	$+0^\circ 51' + 0^\circ 08'$	$+0^\circ 59'$	$+0^\circ 11' - 0^\circ 14'$	$-0^\circ 03'$	$44^\circ 17'$	05

* The theoretical position of the cometary radiant on July 8 is $\alpha = 9^\circ$, $\delta = 46^\circ$; Mr. Denning's values are $\alpha = 3$, $\delta = 49$; also for August 16 our theory gives $\alpha = 54^\circ$, $\delta = 59^\circ$, while Mr. Denning finds from his observations $\alpha = 60^\circ$, $\delta = 59^\circ$.

	T	$\Delta\alpha_3$ $\Delta\alpha_1+\Delta\alpha_2$	$\Sigma\Delta\alpha$	$\Delta\delta_3$ $\Delta\delta_1+\Delta\delta_2$	$\Sigma\Delta\delta$	Ultimate.
	h	parallactic				α δ
Aug. 10	0	+0°67+0°71	+1°38	+0°14+0°03	+0°17	44°96 57°25
	3	+0°84+0°95	+1°79	+0°18+0°41	+0°59	45°37 67
	6	+1°01+0°52	+1°53	+0°21+0°74	+0°95	11 58°03
	9	+1°17-0°23	+0°94	+0°24+0°75	+0°99	44.52 07
	12	+1°34-0°71	+0°63	+0°28+0°49	+0°77	21 57°85
	15	+1°51-0°80	+0°71	+0°32+0°20	+0°52	29 60
	18	+1°68-0°52	+1°16	+0°35-0°05	+0°30	74 38
21	+1°85+0°08	+1°93	+0°39-0°14	+0°25	45°51 33	
Aug. 11	0	+2°01+0°71	+2°72	+0°42+0°03	+0°45	46°30 53

Fig. 4 illustrates this table.

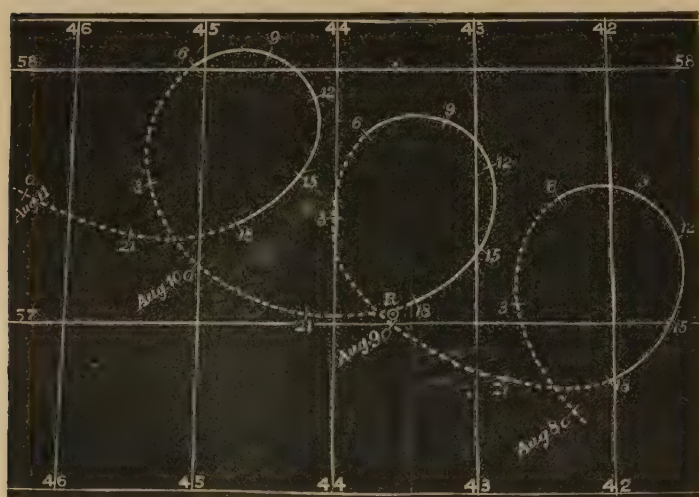


Fig. 4.

TABLE VI.

(Andromedids) $\alpha_0 = 23^{\circ}27$ $\delta_0 = 43^{\circ}12$

	T	$\Delta\alpha_3$	$\Delta\alpha_1+\Delta\alpha_2$	$\Sigma\Delta\alpha$	$\Delta\delta_3$	$\Delta\delta_1+\Delta\delta_2$	$\Sigma\Delta\delta$	Ultimate.
		parallactic.						α δ
Nov. 26	h							
	0	-1 ^o 62	-4 ^o 69	-6 ^o 31	-0 ^o 87	+8 ^o 77	+7 ^o 90	16 ^o 96 51 ^o 08
	3	-1 ^o 48	-6 ^o 65	-8 ^o 13	-0 ^o 80	+5 ^o 08	+4 ^o 28	15 ^o 14 47 ^o 40
	6	-1 ^o 35	-4 ^o 83	-6 ^o 18	-0 ^o 72	+2 ^o 22	+1 ^o 50	17 ^o 09 44 ^o 62
	9	-1 ^o 22	-1 ^o 45	-2 ^o 67	-0 ^o 65	+0 ^o 86	+0 ^o 21	20 ^o 60 43 ^o 33
	12	-1 ^o 08	+2 ^o 73	+1 ^o 65	-0 ^o 58	+1 ^o 20	+0 ^o 62	24 ^o 53 43 ^o 78
	15	-0 ^o 94	+6 ^o 65	+5 ^o 71	-0 ^o 51	+3 ^o 64	+3 ^o 13	28 ^o 98 46 ^o 25
	18	-0 ^o 81	+6 ^o 75	+5 ^o 94	-0 ^o 44	+7 ^o 55	+7 ^o 11	29 ^o 21 50 ^o 23
21	-0 ^o 68	+1 ^o 45	+0 ^o 77	-0 ^o 36	+10 ^o 80	+10 ^o 44	24 ^o 04 53 ^o 56	

	T	$\Delta\alpha_2$	$\Delta\alpha_1 + \Delta\alpha_2$	$\Sigma\Delta\alpha$	$\Delta\delta_2$	$\Delta\delta_1 + \Delta\delta_2$	$\Sigma\Delta\delta$	Ultimate.	δ
	h	parallactic.							
Nov. 27	0	$-0^{\circ}54-4^{\circ}69$	$-5^{\circ}23$	$-0^{\circ}29$	$+8^{\circ}77$	$+8^{\circ}48$	$18^{\circ}04$	$51^{\circ}60$	
	3	$-0^{\circ}40-6^{\circ}65$	$-7^{\circ}05$	$-0^{\circ}22$	$+5^{\circ}08$	$+4^{\circ}86$	$16^{\circ}22$	$47^{\circ}98$	
	6	$-0^{\circ}27-4^{\circ}83$	$-5^{\circ}20$	$-0^{\circ}14$	$+2^{\circ}22$	$+2^{\circ}08$	$18^{\circ}07$	$45^{\circ}20$	
	9	$-0^{\circ}14-1^{\circ}45$	$-1^{\circ}59$	$-0^{\circ}07$	$+0^{\circ}86$	$+0^{\circ}79$	$21^{\circ}68$	$43^{\circ}91$	
	12	$0^{\circ}00+2^{\circ}73$	$+2^{\circ}73$	$0^{\circ}00$	$+1^{\circ}20$	$+1^{\circ}20$	$26^{\circ}00$	$44^{\circ}32$	
	15	$+0^{\circ}14+6^{\circ}65$	$+6^{\circ}79$	$+0^{\circ}07$	$+3^{\circ}64$	$+3^{\circ}71$	$30^{\circ}06$	$46^{\circ}83$	
	18	$+0^{\circ}27+6^{\circ}75$	$+7^{\circ}02$	$+0^{\circ}14$	$+7^{\circ}55$	$+7^{\circ}69$	$30^{\circ}29$	$50^{\circ}81$	
	21	$+0^{\circ}40+1^{\circ}45$	$+1^{\circ}85$	$+0^{\circ}22$	$+10^{\circ}80$	$+11^{\circ}02$	$25^{\circ}12$	$54^{\circ}14$	
Nov. 28	0	$+0^{\circ}54-4^{\circ}69$	$-4^{\circ}15$	$+0^{\circ}29$	$+8^{\circ}77$	$+9^{\circ}06$	$19^{\circ}12$	$52^{\circ}18$	
	3	$+0^{\circ}68-6^{\circ}65$	$-5^{\circ}97$	$+0^{\circ}36$	$+5^{\circ}08$	$+5^{\circ}44$	$17^{\circ}30$	$48^{\circ}56$	
	6	$+0^{\circ}81-4^{\circ}83$	$-4^{\circ}02$	$+0^{\circ}44$	$+2^{\circ}22$	$+2^{\circ}66$	$19^{\circ}25$	$45^{\circ}78$	
	9	$+0^{\circ}94-1^{\circ}45$	$-0^{\circ}51$	$+0^{\circ}51$	$+0^{\circ}86$	$+1^{\circ}37$	$22^{\circ}76$	$44^{\circ}49$	
	12	$+1^{\circ}08+2^{\circ}73$	$+3^{\circ}81$	$+0^{\circ}58$	$+1^{\circ}20$	$+1^{\circ}78$	$27^{\circ}08$	$44^{\circ}90$	
	15	$+1^{\circ}22+6^{\circ}65$	$+7^{\circ}87$	$+0^{\circ}65$	$+3^{\circ}64$	$+4^{\circ}29$	$31^{\circ}14$	$47^{\circ}41$	
	18	$+1^{\circ}35+6^{\circ}75$	$+8^{\circ}10$	$+0^{\circ}72$	$+7^{\circ}55$	$+8^{\circ}27$	$31^{\circ}37$	$51^{\circ}39$	
	21	$+1^{\circ}48+1^{\circ}45$	$+2^{\circ}93$	$+0^{\circ}80$	$+10^{\circ}80$	$+11^{\circ}60$	$26^{\circ}20$	$54^{\circ}72$	
Nov. 29	0	$+1^{\circ}62-4^{\circ}69$	$-3^{\circ}07$	$+0^{\circ}87$	$+8^{\circ}77$	$+9^{\circ}64$	$20^{\circ}20$	$52^{\circ}76$	

Fig. 5 illustrates this table.



Fig. 5.

It may now be seen how difficult and complicated a problem it is to find a radiant point from a series of observations of meteor tracks extending over some length of time.

The accurate method would be the following:—

From a few meteor paths traced on a celestial chart an approximate position of the radiant is to be found; from this the three corrections should be determined for every observation of a meteor; the corrected paths of the meteors again mapped, and then a more accurate position of the radiant may be found.

On the large Sun-spot of 1892 February 5–18, and the Associated Magnetic Disturbance.

(Communicated by the Astronomer Royal.)

As the large spot seen on the Sun 1892 February 5–18 was the largest which has been photographed at Greenwich, and as its presence appears to have been associated with a great magnetic disturbance, some particulars may be of interest, though they must necessarily be imperfect pending the arrival of photographs from India and Mauritius to supplement the Greenwich series.

At Greenwich photographs of the Sun were obtained on five days during the first appearance of the group, viz. on February 5, 13, 16, 17, and 18; and up to the present time on three days during its second appearance, viz. on March 5, 7, and 8. The following table gives the heliographic coordinates of the centre of the great spot, and the total area of the entire group, expressed in millionths of the Sun's visible hemisphere, for each day of observation during its first appearance:—

Date, G. Civil T.			Distance from Centre in terms of Sun's Radius.	Position- Angle from Sun's Axis.	Heliographic		Lati- tude.	Area.	
	h	m			Longitude from Central Meridian.	Longitude from Prime Meridian.		Umbra.	Whole Spot.
Feb. 5	10	24	0.985	118°.4	−81°.9	259°.0	−29°.0	96	1522
13	9	47	0.488	217.5	+19.8	255.6	−29.2	451	2999
16	9	40	0.859	248.4	+58.5	254.9	−28.1	256	2288
17	12	10	0.938	241.3	+70.4	252.3	−29.3	139	1433
18	11	58	0.986	240.6	+82.5	251.3	−30.1	84	1389

The great spot was on the central meridian February 11, 22^h G.C.T. On February 13, when the group was best seen, being then nearer the centre of the disc than on any of the other days of observation, the group extended in heliographic longitude from 270° to 245°, a length of 25°; and in heliographic latitude

from 23° S. to 33° S., a breadth of 10° . The principal spot of the group had a length of 14° , from 263° to 249° , and a breadth of 8° , from 25° S. to 33° S.

The group had greatly diminished in area when it reappeared on the east limb on March 5.

The following table gives the position of the principal spot and area of the entire group, as observed up to the present time, during its second appearance:—

Date, G. Civil T.			Distance from Centre in terms of Sun's Radius.	Position- Angle from Sun's Axis.	Heliographic			Area.	
	h	m			Longitude from Central Meridian	Longitude from Prime Meridian.	Latitude.	Umbra.	Whole Spot.
Mar. 5	9	51	0.927	118°3	-68°4	250°9	-28°8	28	208
7	9	54	0.714	124°0	-42°4	250°4	-28°9	34	510
8	10	39	0.571	132°8	-28°5	250°8	-29°2	35	521

It will be seen that the group has greatly diminished in area during the fortnight in which it was on the further side of the Sun. There seems, however, a slight tendency to increase again, especially with regard to the principal spot, the area of which rose from 101 on March 5 to 369 and 448 on March 7 and 8. The great spot has undergone but little change of place during the interval, for its latitude has remained practically unchanged, and though its longitude, as computed with a sidereal period of 25.38 days, appears to show a slight diminution, this is due to the rotation period of the Sun being longer for high latitudes, the rotation period adopted corresponding to a latitude of about 15° .

A great magnetic disturbance, accompanied by an aurora, occurred on 1892 February 13-14, commencing about a day after the large spot was on the central meridian of the Sun's disc. The following particulars have been drawn up by Mr. Ellis:—

The magnetic disturbance commenced in all elements on February 13 at 5^h 32^m, Greenwich Civil Time, by a sudden increase of declination, horizontal force, and vertical force, accompanied by strong manifestation of earth currents. Large motions were registered in all elements; between February 13, 19^h, and February 14, 3^h, they were unusually large, amounting to more than 1° in declination, the trace having passed off the sheet for one hour shortly after midnight. In horizontal force the disturbance exceeded 0.029 of the whole horizontal force, the trace having similarly passed off the sheet for nearly half an hour at about 22^h, and afterwards for more than $1\frac{1}{2}$ hours from shortly before 1^h to 2 $\frac{1}{2}$ ^h. In vertical force the disturbance was also great, the trace having gone off the sheet in the direction of increasing force from 14 $\frac{1}{2}$ ^h to 19^h, and in the direction of decreasing force from 0 $\frac{1}{2}$ ^h to 2^h; the motion probably exceeded 0.020 of the whole vertical force. The disturbance ceased on the evening of

February 14. An aurora was seen at Greenwich between 0^h and 1^h, by Mr. McClellan.

The disturbance compares in magnitude with those of 1882 April and November, the registered motions being large in all elements on all three occasions. The disturbance of 1882 November was, however, extreme, the motions then registered being apparently in excess even of those of 1882 April and 1892 February.

The following table shows how the recent disturbance compares with previous ones recorded since the commencement of the Greenwich series of solar photographs in 1873.

Particulars of Magnetic Disturbances from the Photographic Registers at the Royal Observatory, Greenwich.

Period of Disturbance. Greenwich Civil Time.	Character of Disturb- ance.	Extreme amplitude of Motion during Disturbance.		
		Declination.	Horizontal Force.	Vertical Force.
1880 Aug. 12 12 ^h to Aug. 14 8 ^h	<i>c</i>	0 1 5	·016	·008
1881 Jan. 31 12 ^h „ Feb. 1 3 ^h	<i>c</i>	1 15	·018	·008
Sept. 12 12 ^h „ Sept. 14 2 ^h	<i>c</i>	1 0	·017	·008
1882 Apr. 16 23 ^h „ Apr. 17 23 ^h	<i>g</i>	1 0+	·030+	·022+
Apr. 20 3 ^h „ Apr. 21 8 ^h	<i>g</i>	1 10+	·020+	·008
Oct. 2 10 ^h „ Oct. 3 3 ^h	<i>c</i>	1 0	·014	no register
Nov. 17 10 ^h „ Nov. 21 4 ^h	<i>g</i>	1 50	·050+	·025
Nov. 21 15 ^h „ Nov. 22 0 ^h	<i>m</i>	0 40	·010	·003
1883 Sept. 16 3 ^h „ Sept. 17 17 ^h	<i>c</i>	0 50	·019	·005+
1884 July 2 19 ^h „ July 4 6 ^h	<i>c</i>	0 40	·018	·007
Oct. 1 22 ^h „ Oct. 3 6 ^h	<i>m</i>	0 30	·010	·004
Nov. 2 13 ^h „ Nov. 3 8 ^h	<i>m</i>	0 45	·012	·005
1885 Mar. 15 10 ^h „ Mar. 16 6 ^h	<i>c</i>	0 55	·010	·009
1886 Mar. 30 8 ^h „ Apr. 1 3 ^h	<i>c</i>	1 5	·020+	·007
1892 Feb. 13 5 ^h „ Feb. 14 18 ^h	<i>g</i>	1 10+	·029+	·015+

In the column “Character of Disturbance” *m* indicates moderate; *c*, considerable; and *g* great.

The amplitudes in the case of Horizontal Force and Vertical Force are given in parts of these forces respectively.

The sign + attached to a measure indicates that the spot of light passed beyond the limit of registration.

Most of these magnetic disturbances occurred when an exceptionally large spot was visible on the Sun near the centre of the disc, or about the time of some great change in a Sun-spot.

Royal Observatory, Greenwich:
1892 March 11.

Addendum.

Since this note was drawn up, Mr. Maunder has found, from an examination of the photographs at Greenwich, that this Sun-spot appeared on the Sun on 1891 November 15, when it came into view close to the east limb as a spot of considerable size. It was also photographed at its appearances in December 1891 and January 1892, so that it has persisted through five rotations, with, however, a remarkable progressive drift in latitude from about 17° S. to 30° S. Several magnetic disturbances have occurred during its presence on the Sun, three being subsequent to that on February 13, described above, viz.: March $1^d 0^h$ to 16^h (moderate), $0^{\circ} 45'$ in declination; March $6^d 9^h$ to $7^d 9^h$ (considerable), $0^{\circ} 50'$ in declination; March $11^d 10^h$ to $13^d 5^h$ (great), $1^{\circ} 15'$ in declination.

Royal Observatory, Greenwich:
1892 March 25.

On the Photographic Magnitude of Nova Aurigæ, as Determined at the Royal Observatory, Greenwich. By W. H. M. Christie, M.A., F.R.S., Astronomer Royal.

A telegram notifying the receipt by Dr. Copeland of an anonymous postcard, which announced the discovery of a new star in *Auriga*, was received at Greenwich at about 5 P.M. on Feb. 1, and a few hours afterwards Mr. Criswick obtained a photograph of the Nova with the 13-inch photographic telescope. Photographs of the new star have been taken at every available opportunity since, with exposures ranging from 15^s to 12^m , and the diameters of the images of the Nova and of certain comparison stars have been measured under the microscope with a filar micrometer, with a view to determining the changes in photographic magnitude of the Nova. Independently of this special object, the discussion has a general interest in relation to the problem of determining the magnitudes of stars for the photographic chart.

On each plate the diameters of the images of the Nova, of four Argelander stars (B.D. + 30° , Nos. 944, 949, 938, and 913), ranging from 8.2 to 8.7 mag. (Argelander), and of a 5.7 mag. star (B.D. + 30° 898), were measured, and the magnitude of the Nova was inferred from those of the comparison stars by means of the formula

$$m = 2.5(\log t - 0.97 \sqrt{d}) + \text{const.}$$

given in the *Monthly Notices*, vol. lii., p. 146, the measures of the comparison stars being used to determine the value of the constant for each plate. The magnitudes of the four 8-9 mag.

stars were taken from Argelander, and that of B.D. + 30° 898 from the *Harvard Photometry* and the *Uranometria Oxoniensis*.

The measures were made independently by Miss Everett and Miss Rix, some of the plates being also measured by myself, and the results obtained by each measurer have been kept separate, as there is decided evidence of personality. The values of the constant obtained from the measures of the four 8-9 mag. stars and of the 5·7 mag. star respectively, are also exhibited separately (as c_1 and c_2), with the values of the magnitude of the Nova, deduced by means of the mean values of c_1 and c_2 for the two or three exposures on each plate. As a rule, each measurer made four measures of each image of the Nova and of the 5·7 mag. star, and two measures of each image of each of the four 8-9 mag. stars.

The 5·7 mag. star, B.D. + 30° 898, is about 1° from the centre of the plate, and the image is somewhat diamond shaped. In this and other similar cases two diameters at right angles have been measured, and the geometric mean taken.

The results are tabulated below.

The initials AE, ER, and WC are those of Miss Everett, Miss Rix, and Mr. Christie respectively.

MAGNITUDES OF NOVA AURIGÆ, 1892.

Derived from comparison with four small stars, mag. 8·2, 8·2, 8·7, 8·7.

Date and Exposure.	Value of c_1 .			Magnitude of Nova.		
	AE.	ER.	WC.	AE.	ER.	WC.
Feb. 1.		No. 247.	Ilford Plate.	Photogr. Mr. Criswick.		
7 ^m	10·22	10·30	10·23	4·29	4·60	4·53
Feb. 2.		No. 249.	Ilford Plate.	Photogr. Mr. Davidson.		
3 ^m	9·09	...	...	4·05	...	...
2 ^m	8·88	..	...	4·21	...	...
1 ^m	9·19	...	...	3·85	...	...
Mean	9 05			4 04		
Feb. 2.		No. 250.	Ilford Plate.	Photogr. Mr. Davidson.		
8 ^m	8·44	...	...	3·69	...	...
6 ^m	8·43	...	...	3·60	...	...
Mean	8 434			3 64		
Feb. 2.		No. 251.	Lumière Plate.	Photogr. Mr. Davidson.		
12 ^m	9·76	9·65	...	2·98	2·67	...
30 ^a	9·30	9·01	...	3·76	3·51	...
15 ^a	9·46	9·03	...	3·56	3·25	...
Mean	9 51	9 23		3 43	3 14	

Date and Exposure.	Value of c_1 .			Magnitude of Nova.		
	AE.	ER.	WC.	AE.	ER.	WC.
Feb. 3.	No. 255. <i>Lumière Plate.</i>			Photogr. Mr. Furner.		
4 ^m	9.11	8.65	...	3.90	3.49	...
2 ^m	9.13	8.66	...	3.77	3.84	...
1 ^m	9.20	8.91	...	3.32	3.71	...
Mean	9.15	8.74		3.66	3.68	

Feb. 3.	No. 256. <i>Lumière Plate.</i>			Photogr. Mr. Furner.		
8 ^m	8.59	8.24	...	3.35	3.54	...
6 ^m	8.51	8.00	...	3.75	3.82	...
Mean	8.55	8.12		3.55	3.68	

Feb. 3.	No. 257. <i>Lumière Plate.</i>			Photogr. Mr. Furner.		
12 ^m	8.49	8.28	8.52	3.84	2.82	3.68
30 ^s	8.88	8.48	8.57	3.79	3.27	3.66
15 ^s	8.98	8.49	8.77	3.77	3.14	3.46
Mean	8.77	8.42	8.61	3.80	3.08	3.60

Feb. 12.	No. 262. <i>Lumière Plate.</i>			Photogr. Miss Everett.		
12 ^m	9.14	8.72	8.83	4.28	3.75	3.82
30 ^s	9.20	8.50	8.43	4.38	3.32	3.45
15 ^s	9.59	8.74	8.71	4.08	3.37	3.12
Mean	9.28	8.65	8.65	4.25	3.48	3.46

Feb. 12.	No. 263. <i>Lumière Plate.</i>			Photogr. Miss Everett.		
8 ^m	8.82	8.86	...	4.19	4.18	...

Feb. 13.	No. 264. <i>Ilford Plate.</i>			Photogr. Mr. Criswick.		
8 ^m	8.48	8.50	...	4.20	4.23	...
6 ^m	8.71	8.42	...	4.12	4.31	..
Mean	8.60	8.46		4.16	4.27	

Feb. 13.	No. 265. <i>Ilford Plate.</i>			Photogr. Mr. Criswick.		
12 ^m	8.61	8.04	...	4.18	4.26	...
30 ^s	8.45	7.96	...	4.83	4.43	...
15 ^s	8.53	7.89	...	4.98	4.53	...
Mean	8.53	7.96		4.66	4.41	

Date and Exposure.	Value of c_1 .			Magnitude of Nova.		
	AE.	ER.	WC.	AE.	ER.	WC.
Feb. 13.	No. 267. <i>Ilford Plate.</i>			Photogr. Mr. Criswick.		
4 ^m	8.29	7.66	...	4.43	3.98	...
2 ^m	8.33	7.76	...	4.71	4.23	...
1 ^m	8.46	7.71	...	4.56	4.23	...
Mean	8.36	7.71		4.57	4.15	
Feb. 18.	No. 271. <i>Ilford Plate.</i>			Photogr. Mr. Criswick.		
12 ^m	9.20	9.39	...	3.64	2.96	...
30 ^s	9.03	9.11	...	3.99	3.86	...
15 ^s	8.98	8.52	...	4.04	3.83	...
Mean	9.07	9.01		3.89	3.55	
Feb. 18.	No. 273. <i>Ilford Plate.</i>			Photogr. Mr. Criswick.		
4 ^m	9.13	9.14	...	4.04	3.89	...
2 ^m	9.35	9.26	...	4.19	3.87	...
1 ^m	9.26	9.25	...	4.04	3.89	...
Mean	9.24	9.22		4.09	3.88	
Feb. 22.	No. 275. <i>Mawson & Swan Plate.</i>			Photogr. Miss Rix.		
12 ^m	9.61	...	...	3.97	...	...
30 ^s	9.79	...	...	4.72	...	...
15 ^s	9.70	...	...	4.90	...	...
Mean	9.70			4.53		
Feb. 22.	No. 277. <i>Mawson & Swan Plate.</i>			Photogr. Miss Rix.		
4 ^m	9.90	...	...	5.23	...	...
2 ^m	10.20	...	...	4.96	...	...
1 ^m	9.80	...	...	5.18	...	...
Mean	9.96			5.12		
Mar. 7.	No. 279. <i>Mawson & Swan Plate.</i>			Photogr. Miss Everett.		
12 ^m	8.97	...	...	4.62	...	...
30 ^s	9.00	...	...	5.29	...	...
15 ^s	8.49	...	...	5.37	...	...
Mean	8.82			5.09		

March 1892.

Magnitude of Nova Aurigæ.

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Date and Exposure.	Value of c_2 .			Magnitude of Nova.		
	AE.	ER.	WC.	AE.	ER.	WC.
Mar. 7.		No. 280.	<i>Mawson & Swan Plate.</i> Photogr. Miss Russell.			
4 ^m	8.37	...	...	4.99	...	...
2 ^m	8.36	...	...	5.21	...	...
1 ^m	8.29	...	...	4.81	...	...
Mean	8.34			5.00		

Mar. 9.		No. 283.	<i>Ilford Plate.</i> Photogr. Miss Everett.			
12 ^{ua}	8.77	...	...	6.01	...	...
30 ^s	8.90	...	...	6.21	...	...
15 ^t	9.23	...	...	6.08	...	...
Mean	8.96			6.10		

Derived from comparison with a star, B. D. + 30° 898, mag. 5.7.

Date and Exposure.	Value of c_2 .			Magnitude of Nova.		
	AE.	ER.	WC.	AE.	ER.	WC.
Feb. 1.		No. 247.	<i>Ilford Plate.</i> Photogr. Mr. Criswick.			
7 ^m	...	...	...	...	...	...
Feb. 2.		No. 249.	<i>Ilford Plate.</i> Photogr. Mr. Davidson.			
3 ^{un}	9.58	...	...	4.59	...	...
2 ^m	9.33	...	...	4.75	...	...
1 ^m	9.90	...	...	4.39	...	...
Mean	9.60			4.58		

Feb. 2.		No. 250.	<i>Ilford Plate.</i> Photogr. Mr. Davidson.			
8 ^m	8.85	...	...	4.38	...	...
6 ^{ua}	9.40	...	...	4.30	...	...
Mean	9.13			4.34		

Feb. 2.		No. 251.	<i>Lumière Plate.</i> Photogr. Mr. Davidson.			
12 ^m	10.80	10.62	...	4.18	3.96	...
30 ^s	10.55	10.37	...	4.96	4.74	...
15 ^t	10.78	10.48	...	4.76	4.54	...
Mean	10.71	10.49		4.63	4.41	

Feb. 3.		No. 255.	<i>Lumière Plate.</i> Photogr. Mr. Furner.			
4 ^m	9.38	8.63	...	4.30	3.42	...
2 ^m	9.58	8.65	...	4.17	3.77	...
1 ^m	9.68	8.73	...	3.72	3.64	...
Mean	9.55	8.67		4.06	3.61	

Date and Exposure.	Value of c_2 .			Magnitude of Nova.		
	AE.	ER.	WC.	AE.	ER.	WC.
Feb. 3.	No. 256. <i>Lumière Plate.</i>			Photogr. Mr. Furner.		
8 ^m	8.95	8.45	...	3.83	3.70	...
6 ^m	9.10	8.10	...	4.23	3.98	...
Mean	9.03	8.28		4.03	3.84	
Feb. 3.	No. 257. <i>Lumière Plate.</i>			Photogr. Mr. Furner.		
12 ^m	8.90	9.15	9.35	4.41	3.69	4.71
30 ^s	9.48	9.13	9.63	4.36	4.14	4.69
15 ^s	9.63	9.58	9.93	4.34	4.01	4.49
Mean	9.34	9.29	9.64	4.37	3.95	4.63
Feb. 12.	No. 262. <i>Lumière Plate.</i>			Photogr. Miss Everett.		
12 ^m	9.33	9.05	9.28	4.54	4.49	4.88
30 ^s	9.45	9.58	9.73	4.64	4.06	4.51
15 ^s	9.83	9.53	10.13	4.34	4.11	4.18
Mean	9.54	9.39	9.71	4.51	4.22	4.52
Feb. 12.	No. 263. <i>Lumière Plate.</i>			Photogr. Miss Everett.		
8 ^m	9.15	9.45	...	4.52	4.77	...
Feb. 13.	No. 264. <i>Ilford Plate.</i>			Photogr. Mr. Criswick.		
8 ^m	9.45	9.15	...	5.12	4.75	...
6 ^m	9.58	8.80	...	5.04	4.83	...
Mean	9.52	8.98		5.08	4.79	
Feb. 13.	No. 265. <i>Ilford Plate.</i>			Photogr. Mr. Criswick.		
12 ^m	9.60	8.70	...	5.20	5.07	...
30 ^s	9.48	8.78	...	5.85	5.24	...
15 ^s	9.58	8.83	...	6.00	5.34	...
Mean	9.55	8.77		5.68	5.22	
Feb. 13.	No. 267. <i>Ilford Plate.</i>			Photogr. Mr. Criswick.		
4 ^m	9.53	8.60	...	5.58	4.71	...
2 ^m	9.48	8.20	...	5.86	4.96	...
1 ^m	9.53	8.53	...	5.71	4.96	...
Mean	9.51	8.44		5.72	4.88	

Date and Exposure.	Value of c_s .			Magnitude of Nova.		
	AE.	ER.	WC.	AE.	ER.	WC.
Feb. 18.	No. 271. <i>Ilford Plate.</i>			Photogr. Mr. Criswick.		
12 ^m	10.00	10.40	...	4.56	4.34	...
30 ^s	10.05	10.53	...	4.91	5.24	...
15 ^a	9.93	10.23	...	4.96	5.21	...
Mean	9.99	10.39		4.81	4.93	

Feb. 18.	No. 273. <i>Ilford Plate.</i>			Photogr. Mr. Criswick.		
4 ^m	8.90	8.95	...	3.94	3.77	...
2 ^m	9.23	9.10	...	4.09	3.75	...
1 ^m	9.28	9.25	...	3.94	3.77	...
Mean	9.14	9.10		3.99	3.76	

Feb. 22.	No. 275. <i>Mawson & Swan Plate.</i>			Photogr. Miss Rix.		
12 ^m	10.58	...	...	4.96	...	...
30 ^s	10.70	...	...	5.71	...	...
15 ^a	10.78	..	...	5.89	...	...
Mean	10.69			5.52		

Feb. 22.	No. 277. <i>Mawson & Swan Plate.</i>			Photogr. Miss Rix.		
4 ^m	9.93	...	...	5.36	...	...
2 ^m	10.53	...	...	5.09	...	...
1 ^m	9.80	...	...	5.31	...	...
Mean	10.09			5.25		

MAR. 7.	No. 279. <i>Mawson & Swan Plate.</i>			Photogr. Miss Everett.		
12 ^m	9.88	...	...	5.25	...	...
30 ^s	9.28	...	...	5.92	...	...
15 ^a	9.25	...	...	6.00	...	...
Mean	9.45			5.72		

MAR. 7.	No. 280. <i>Mawson & Swan Plate.</i>			Photogr. Miss Russell.		
4 ^m	8.53	...	...	5.32	...	...
2 ^m	8.65	...	...	5.54	...	...
1 ^m	8.83	...	...	5.13	...	...
Mean	8.67			5.33		

Date and Exposure.	Value of c_2 .			Magnitude of Nova.		
	AE.	ER.	WC.	AE.	ER.	WC.
Mar. 9.	No. 283. <i>Iford Plate.</i>			Photogr. Miss Everett.		
12 ^m	9.38	...	...	6.45	...	...
30 ^s	9.18	...	...	6.65	...	...
15 ^s	9.63	...	...	6.52	...	...
Mean	9.40			6.54		

In the values of the constant deduced by each measurer there appear to be no systematic differences between the long exposures and the short, and the mean of the values for the two or three exposures on each plate has therefore been used as the value of the constant for the plate. The range of exposures from 15^s to 12^m, representing 4.2 magnitudes, corresponds approximately to the difference in photographic magnitude between the Nova and the 8-9 mag. comparison stars. It may here be explained that the constant c represents the magnitude of the star which, with an exposure t , would give a diameter d'' for the photographic image, such that $\log t - 0.97 \sqrt{d} = 0$, or $\log t = 0.97 \sqrt{d}$. The following are the values of the exposure in seconds required to give the corresponding diameters of image for stars of magnitude $= c$.

Diameter.	Exposure.	Diameter.	Exposure.
"	^s	"	^s
1	9.3	3	47.9
1½	15.4	4	87.1
2	23.5	5	147.6

Thus, if we take the value of the constant c_1 , found for Photo. 247 on February 1, we should have a star of 10.25 mag. photographed in 15½^s with a diameter of 1½'', which may be considered to give a distinctly measurable disc. It will be seen that the values of the constant on different nights and with different plates differ considerably, so that in some cases we should only get stars of 8½ mag. photographed, instead of 10¼ mag., with an exposure of 15½^s. The values of c_2 are generally greater than those of c_1 , implying that the star B.D. + 30° 898 is photographically brighter than 5.7 mag., if we take the four 8-9 mag. stars as our standard. The photographic magnitude of B.D. + 30° 898 thus deduced from the mean of all the measures is 5.04, the difference between the determinations by Miss Everett and Miss Rix respectively being only 0.03 mag.

Both in the values of the constant (c_1 and c_2) and in the deduced magnitudes of the Nova (m_1 and m_2) there is decided evidence of personality between Miss Everett and Miss Rix, the mean values of AE-ER being

in $c_1 + 0.34$ mag.; in $m_1 + 0.27$ mag.; in $c_2 + 0.39$ mag.; in $m_2 + 0.33$ mag.

The close correspondence between the values of the personality in c_1 and m_1 , and in c_2 and m_2 , respectively, would imply that the difference in the deduced magnitudes of the Nova results mainly from personality in the measurement of the comparison stars. This inference is supported by a comparison of my own results with Miss Everett's, though mine are hardly numerous enough to give any trustworthy determination of personality. The mean values found for AE—WC are

in $c_1 + 0.35$ mag.; in $m_1 + 0.39$ mag.; in $c_2 - 0.24$ mag.; in $m_2 - 0.14$ mag.

The values for AE—ER for the corresponding exposures being

in $c_1 + 0.43$ mag.; in $m_1 + 0.59$ mag.; in $c_2 + 0.10$ mag.; in $m_2 + 0.36$ mag.

The following table exhibits the magnitude of the Nova for each day, deduced from all the measures of each observer by comparison with the four 8-9 mag. stars, and with the 5.7 mag. star, respectively, the number of images of the Nova measured being indicated by the suffix; and the means for all the observers on each day. In forming these means it has been thought better not to apply any correction for personality, which must necessarily be subject to much uncertainty; but to take the simple mean of all the results by each observer, with weights proportional to the number of images of the Nova measured. The means m_1 and m_2 are formed from the comparisons with the four 8-9 mag. stars and the 5.7 mag. star respectively, and the final means in the last column are the means of m_1 and m_2 , after applying a correction of -0.66 mag. to the latter, to make them comparable, this being the difference between the assumed magnitude for this star (5.7) and that deduced from the photographs relatively to the four 8-9 mag. stars—viz., 5.04 mag.

*Photographic Magnitude of Nova Aurigæ from comparisons with four stars
8-9 mag. with B.D. + 30° 898.*

1892.		AE. mag.	ER. mag.	WC. mag.	AE. mag.	ER. mag.	WC. mag.	Means Adopted.		
								m_1 mag.	m_2 mag.	Mag.
Feb.	1	4.29 ₁	4.60 ₁	4.53 ₁	...	...	...	4.47	...	4.47
	2	3.71 ₈	3.14 ₃	...	...	4.41 ₃	...	3.55	4.50	3.70
	3	3.69 ₈	3.45 ₈	3.60 ₃	4.17 ₇	3.79 ₈	4.63 ₃	3.57	4.08	3.50
	12	4.23 ₄	3.66 ₄	3.46 ₃	4.51 ₄	4.36 ₄	...	3.81	4.44	3.80
	13	4.50 ₈	4.28 ₈	...	5.55 ₈	4.98 ₈	...	4.39	5.27	4.50
	18	3.99 ₆	3.72 ₆	...	4.35 ₆	4.40 ₆	...	3.86	4.38	3.79
	22	4.83 ₆	...	...	5.39 ₆	...	...	4.83	5.39	4.78
Mar.	7	5.05 ₆	...	...	5.53 ₆	...	...	5.05	5.53	4.96
	9	6.10 ₆	...	...	6.54 ₆	...	...	6.10	6.54	5.99

It would seem from these results that the Nova brightened decidedly from February 1 to February 3, when it was at its maximum; and that after diminishing considerably in brightness it attained a secondary maximum about February 18, since which date it has become gradually fainter. Unfortunately, owing to cloudy weather, the record is very imperfect. It will be remarked that the Nova appears to be much brighter photographically than it is to the eye, judging from the visual estimations of magnitude which have been published.

Royal Observatory, Greenwich:
1892 March 11.

Preliminary Note on the Magnitude of the New Star in Auriga.

Communicated by Professor C. Pritchard, D.D., F.R.S.

Observations of the magnitude of the new star in *Auriga* have been made at this Observatory on all available occasions, and the results are here presented to the Society. The determinations of magnitude have been made to depend both on photometric measures with the wedge photometer and on photographs taken with the 13-inch photographic telescope.

The Nova has been compared with the following stars, whose magnitudes have been assumed from the *Uranometria Nova Oxoniensis*:

χ Aurigæ	mag. 5.08
ϕ Aurigæ	„ 5.44
26 Aurigæ	„ 5.63
Lal. 10143	„ 5.84

The results of the comparisons with the wedge photometer are shown in the following table:

Date 1892.	Observed Photometric Magnitude.	Stars of Comparison.
Feb. 3	4.82	χ Aurigæ.
5	5.11	χ , ϕ Aurigæ.
7	4.96	χ , ϕ , 26 Aurigæ.
11	5.16	ϕ , 26 Aurigæ.
13	5.28	ϕ , 26 Aurigæ.
16	5.44	χ , ϕ Aurigæ.
18	5.60	ϕ , 26 Aurigæ, Lal. 10143.
22	5.51	26 Aurigæ, Lal. 10143.
28	5.64	ϕ , 26 Aurigæ.
Mar. 7	5.89	Lal. 10143.

A series of photographs has likewise been taken of the Nova and of the neighbouring stars. The magnitude has been deduced, after measurement of the diameter of the photographic image, by means of a curve drawn in the manner suggested in the *Proceedings of the Royal Society*, May, 1886. This curve is based on the diameters of stars ranging from β Tauri (mag. 1.79) to *Piazzi* v. 62 (mag. 6.20).

Photographic Magnitude of Nova Auriga.

Date 1892.	Photographic Magnitude.
Feb. 11	5.09
13	5.35
16	5.39
18	5.70
Mar. 7	5.82

P.S.—The following further determinations of the magnitude of the Nova have been made since the date of this paper :—

	By Wedge Photometer. mag.	By Photographic Record.
Mar. 8	5.96	
12	6.93	7.13
13	7.07	
14	7.25	
18	8.76	8.93
19	9.10	9.26
22	9.32	

Oxford University Observatory :
1892 March 23.

The New Star in Auriga. By George Knott, B.A., LL.B.

The new star in *Auriga* was first seen here on the evening of February 3, when it appeared to be equal in magnitude to χ *Aurigæ*. As seen in the telescope its colour was yellowish. Viewed with a small direct-vision spectroscope, which fits over the field-lens of an ordinary negative eye-piece, mag. power 200, its spectrum was seen to be crossed by four broad bright lines in the green and blue. Lettering these in order from green to blue, *b* was in mid-distance between *a* and *d*, and *c* was at about one-third of the distance from *d* to *b*. The brightest of the four lines was *d* (solar F?), and *c* was the narrowest and faintest. On receiving, later in the evening, Dr. Copeland's Edinburgh Circular, I looked for other bright lines, and glimpsed one in the violet.

The red end of the spectrum was very bright, but I failed to distinguish c, perhaps owing to want of definition in this part of the spectrum. On February 5 the four bright lines in the green and blue were again well seen, the order of brightness appearing to be *d b c a*. A faint bright line was seen in the violet, and one in the yellow or orange, and c was perhaps doubtfully distinguishable. On February 13 the order of brightness was noted *d, a b, c*.

The weather has been very unfavourable here for observation, but I give below my magnitude estimates of the new star. They were made with a binocular field-glass, mag. power 5, and the magnitudes of the comparison stars, χ and 26 *Aurigæ* and L 10143, were adopted from Professor Pritchard's *Uranometria Nova Oroniensis*. The light of the new star would seem to have been subject to slight fluctuations, but perhaps these may be in part due to errors of observation.

Feb.	3	Mag.	Feb.	23	Mag.
	5	5.1		25	5.6
	7	5.1		27	5.6
	11	5.1		28	5.5
	12	5.1		29	5.7
	13	5.3	Mar.	5	5.8
	20	5.8		7	6.1
	22	5.9			

The star D.M. + 30° 9' 13, 8.7 mag., precedes the new star 1^m 51^s.05, 7^m.68 N. There is an 11.0 mag. star in the *nf* quadrant, measures of which relative to the new star were taken in position and distance with a filar micrometer on two nights with the following results:—

Pos.	Dist.	Epoch.
32° 18	80" 28	1892.134
31.88	80.31	1892.178
Means 32.03	80.29	1892.16

A reduction of these coordinates gives as the place of the 11.0 mag. star relative to the new star $\Delta\alpha + 3^s 29$, $\Delta\delta + 68'' 07$.

From an observation on the meridian on February 20, I found the approximate Mean Right Ascension of the new star for 1892.0 to be 5^h 25^m 3^s.33. The colour of the new star has been noted by me to be pale yellow, or pale yellow with a slight tinge of orange.

Knowles Lodge, Cuckfield:
1892 March 9.

Note on the Spectrum of Nova Aurigæ. By E. W. Maunder.

The appearance of the new star discovered by Dr. Anderson near χ *Aurigæ* happened at a most unfortunate time for spectroscopic observation at the Greenwich Observatory, since the old 12 $\frac{3}{4}$ inch refractor had been dismantled some months, and its successor, the 28-inch, had not come to hand. There was, therefore, at the time no telescope available to which either of the spectroscopes of the Observatory could be applied. Under these circumstances the best course appeared to be to try and utilise the object-glass prism presented to the Observatory by Sir Henry Thompson, and the Astronomer Royal directed me to attach it to the 9-inch photographic telescope which the same donor had also given. As, however, that telescope had been employed for a different work, and as, therefore, the prism had never been tested with it, several serious difficulties were encountered, and, partly owing to the delays thus caused, and partly to the continued cloudy weather, which greatly hindered the work of adjustment, it was not until February 18 that any exposure could be made upon the Nova, and this was rendered useless by the cloudy state of the sky. On February 22 an exposure was, however, made more successfully, though two serious drawbacks prevented the photograph being a sharp one. The first difficulty was that the telescope-tube was not long enough to get a good focus, and the second that the enormous weight of the Lassell telescope, to which the Thompson instrument is attached, causes it to flex to a marked amount when off the meridian, and hence the star can with difficulty be made to preserve the same position in declination during a long exposure, and of course any drift in declination must be fatal to the definition of the lines.

The plate, to which an exposure of 70 minutes was given, however, shows the more pronounced lines in the spectrum, though, for the reasons above mentioned, their definition is only poor. A preliminary measurement and reduction of the photograph give the following positions for the lines:—

Line.	Bright lines.	Dark lines.
	4919	
F	4860	
	4629	
	4580	
	4547	
	4510	
	4472	
G	4340	4316
		F F 2

Line.	Bright lines.	Dark lines.
	4229	4212
	4174	4155
<i>h</i>	4101	4085
H	3968	3953
K	3933	3913
<i>a</i>	3887.5	
<i>β</i>	3834	

The bright lines due to hydrogen were recognised by their correspondence in position with the dark lines in the spectrum of *β Tauri*, which was photographed in close proximity to that of the Nova, and Dr. Huggins's values have been adopted for their wave-lengths. The positions of the other bright lines, and of the dark lines, have been computed from the measures by the use of an interpolation formula.

The mean displacement of the dark lines relative to the corresponding bright lines was 18.3 tenthmeters, and corresponds to a motion of relative approach of 820 miles a second. This is probably a considerably exaggerated value, the want of fine definition in the photograph rendering the measures necessarily rough, and tending to exaggerate the measures of displacement.

On the same evening, and with the same instrument, I succeeded in obtaining a view of the visual part of the spectrum. A positive eye-piece of magnifying power about 80 was used. The spectrum was bright, and five bright lines were seen in the green, one in the orange, one in the extreme red, and two lines between these two last named. Other bright lines were also seen in the blue, but these were clearly those seen in the photograph.

Of the lines in the green, the first was clearly the F line; and the second, proceeding in the direction of the less refrangible rays, was the line measured on the photograph as at λ 4919.

Adopting the interval between these two lines as unity, that between the second and third was estimated as about 1.4 (for, of course, no measures could be made), between the third and fourth as 2.4, and between the fourth and fifth as 2.0. This would make the fifth line not far from E, the fourth line near *b*, but further towards the blue, and the third line very near the chief nebular line. So rough an estimation, of course, leaves it quite an open question as to whether these lines really coincided with the lines named or not. The line supposed to be near E appeared to be a diffused band, rather than a sharply defined line.

The line in the extreme red, supposed to be C, was very bright; the line in the orange, supposed to be D, was less so; the two which lay between C and D were less bright.

This occasion, February 22, was the only one in which I have had the opportunity of examining or photographing the spectrum

of the Nova, and the instrument referred to, the Thompson photographic telescope, aperture 9 inches, with a prism of 15° before the object-glass, was the only instrument I was able to employ.

Blackheath:

1892 March 11.

Photograph of the Region of Nova Aurigæ.

By Isaac Roberts, F.R.S.

The region of *Nova Aurigæ*, with R.A. $5^{\text{h}} 25^{\text{m}}$, and Decl. $+30^{\circ} 21'$ as the centre, was photographed with the 20-inch reflector on the night of February 5, which was the first night with a clear interval, after the receipt of the Edinburgh Circular No. 22 announcing the discovery. Since that date the photographs described in the sequel have been taken.

The photograph now presented is an enlargement to the scale of one centimetre to four minutes of arc from a negative taken on February 18 with an exposure of three hours. The plate was so placed in the reflector that the star D.M. No. 899, Zone 30° , mag. 6.2, should be simultaneously photographed with the Nova, and on two plates the star 26 *Aurigæ* was photographed with the Nova.

The photographs obtained have been examined by aid of the pantograver, and the photo-images of the Nova, of D.M. No. 899, and of 26 *Aurigæ* measured to 0.0001 of an inch diameter. The results are given in the following table:—

Table of measured Photo-diameters.

Date when Negative was taken.	Duration of exposure of Negative.	Diameter of Nova.		Diameter of D. M. No. 899, Zone 30° degrees.		Diameter of 26 <i>Aurigæ</i> .	
		In parts of an inch.	In seconds of arc.	In parts of an inch.	In seconds of arc.	In parts of an inch.	In seconds of arc.
1892.							
Feb. 5	45 ^m	0.0169	34.9	0.0174	35.9	...	...
13	15 ^m	0.0137	28.3	...	...	0.0142	29.3
13	5 ^m	0.0128	26.5	...	...	0.0127	26.3
18	3 ^h	0.0217	44.7	0.0203	41.9	...	...
22	20 ^m	0.0137	28.1	0.0152	31.4	...	...
22	5 ^m	0.0130	26.8	0.0146	30.0	...	...
25	5 ^m	0.0130	26.8	0.0147	30.2	...	...
25	20 ^m	0.0142	29.3	0.0144	29.7	...	...

The following observations upon the appearance of the photo-image of the Nova and of the comparison stars were made during the examination of the negatives under a magnifying power of 24 diameters.

February 5, exposure 45 min.: the image of the Nova is not as well defined at the margin as that of the star D.M. No. 899.

February 13, exposures 15 min. and 5 min. respectively: the image of the Nova is fairly well defined round the margin on each of the photographs.

February 18, exposure 3 hours: the margins of both the Nova and the comparison star No. 899 are nebulous and undefined. There are six stars visible round the Nova, within a radius distance of 50 secs. of arc, and there are also twelve stars round No. 899 within a radius of 50 secs.

The four negatives taken on February 22 and 25 show both the Nova and star No. 899 with well-defined margins, the exposures being respectively 5 mins. and 20 mins.

It will be observed, on examination of the table of the measured diameters of the Nova and the comparison stars, that no decided change in the brightness of the Nova has taken place during the interval between February 5 and 25, if we adopt the photographs with 20 mins. exposure on the 25th as the standard; but if we adopt the image formed with 5 mins. exposure, there would be shown a fading of the light of the Nova between February 18 and 25.

Photograph of the Region of Nova Cygni. By Isaac Roberts, F.R.S.

Nova Cygni was discovered by Dr. J. F. J. Schmidt at Athens on 1876 November 24, and its co-ordinates for 1878 are given R.A. $21^h 36^m 55^s$, Decl. $+42^\circ 17'9''$. Between that date and the year 1882 many observations concerning the Nova are recorded, but I shall refer only to the catalogue and chart by Drs. Copeland and Lohse, published in vol. ii. of *Copernicus*. These give clear evidence of great care exercised by the observers and delineators in their preparation; and by their aid and the photographs now presented we are enabled to infer that several changes in the stars have taken place during the past ten years.

Two photographs are before us which are enlargements from a negative taken on 1891 September 27, with an exposure of 2 hours in the 20-inch reflector; one of them is enlarged to the scale of one centimetre to four minutes of arc; the other is to the same scale as the chart of the region of the Nova referred to above, which scale is one centimetre to one second of arc.

On the chart is drawn a circle enclosing a space fifteen minutes of arc in diameter, with the Nova as the centre, and I have drawn with pencil on the photograph a line enclosing a space very nearly coincident with that of the chart; we are thus enabled to make comparisons of the two with little trouble. By inspection we soon observe that changes have taken place in the brightness of some of the stars, and also some changes in

their relative positions; but I do not intend to discuss these in great detail for the reason that Dr. Copeland will probably re-survey this region with the aid of the instruments employed by him in the first survey. I will therefore now only refer to a few of the most conspicuous changes in the stars which the photograph indicates.

The stars on the chart catalogue are numbered from 1 to 113, and their magnitudes, position-angle, distance, co-ordinates, and other particulars are given. On the large-scale photograph I have numbered with white ink the stars corresponding with them, to which I will now refer. The Nova is within the white circle.

List of the Stars which have undergone conspicuous change since the year 1878.

No. 2 star, 12.2 mag. on chart, is about 14 mag. on photograph.

6	14.0	16
12	11.8	13
18	12.6	15
21	11.8	13
30	11.4	14
46	13.0	12

No. 47 is on the photograph a double star, the *comes* being about 14th mag.

The Nova is not given on the chart, but on the photograph it is a prominent object as a star of about 13th mag.

No. 84 star has moved in position-angle from *np* star No. 86 to *n*.

No. 99 star on the chart is single, but on the photograph it is double.

No. 104 star on chart is 11.4 mag., and on the photograph is about 13th mag.

No. 105 star is single on chart, and double on the photograph.

Some of the changes in magnitude which have been indicated may be due, of course, to the well-known differences between eye estimations and photographic diameters, but this only emphasises the necessity of repeating the eye observations, and also, after a sufficient interval of time has elapsed, taking other photographs of the region.

On an Annual Variation in the R—D Discordance.

By H. H. Turner, M.A., B.Sc.

In connection with a discussion of the distribution of temperature in the Transit Circle Room at the Royal Observatory, Greenwich, it occurred to me to inquire whether the R—D discordance varies during the year. Such a variation might be an indication of the dependence of part, or the whole, of the discordance upon the temperature distribution. The major part of the discordance is usually ascribed to flexure of the instrument; and in the case of the Greenwich Transit Circle the closeness with which the law of the sine zenith-distance satisfies the observations certainly points to the probability of this hypothesis. But there is a curious anomaly in the fact that whereas the horizontal flexure thus indicated would be nearly 1'', observations made with the collimators in the ordinary way give a very small horizontal flexure.

It has further been noticed that the residuals of R—D, after comparing the actual observations with this assumed simple law, are persistent in sign year after year at the same zenith-distance, and suggest a secondary discordance not included in the assumed formula. The R—D may in fact be a complex phenomenon, and part of it at least may be due to other causes than flexure. This remark will now be illustrated by a discussion of the residuals for the years 1883–1890, during which the principal (flexure) term of the R—D has remained sensibly constant. Previously to 1883 the range of stars available in reflexion observations was much more restricted, owing to the mounting of the collimators, and the results are thus not so readily comparable. In the years 1883–1890 the results have been grouped in as nearly as possible the same manner; and the mean of the residuals for corresponding groups is given opposite the approximate mean Z. D. of the group.

Mean Residuals of R—D for Years 1883–1890.

Mean. Z.D.	North Stars.	South Stars.	N—S.	Mean Z.D.	North Stars.	South Stars.	N—S.
68 $\frac{1}{2}$	+0''40	—0''83	+1''23	36	+0''24	+0''36	—0''12
65 $\frac{1}{2}$	+0'36	—0'24	+0'60	30	+0'05	+0'38	—0'33
62	—0'24	—0'32	+0'08	26	+0'03	+0'25	—0'22
59	—0'55	—0'18	—0'37	24	0'00	+0'07	—0'07
56	—0'25	—0'28	+0'03	20	+0'02	+0'08	—0'06
52	+0'18	—0'0	+0'24	16 $\frac{1}{3}$	+0'06	...	...
48	+0'02	—0'06	+0'08	12 $\frac{1}{3}$	+0'18	—0'22	+0'40
42	+0'31	+0'18	+0'13	9 $\frac{1}{2}$	+0'23	...	...

From accurate measurements recently made, it appears that in reflexion observations made at zenith-distances less than 21° or greater than 62° the full aperture of the telescope objective is not used, and hence the corresponding groups should be excluded from the present discussion. From the intermediate groups it will be seen that both for N. and S. stars the residuals are negative for large zenith-distances and positive for small, though the change takes place earlier for N. stars than for S. A smooth curve shows a secondary discordance amounting to at least $0''.5$ not included in the standard formula. It is under consideration whether this discordance may not be due to the fact that the direct and reflected rays do not strike the general mass of air in the observing room at the same point, and may suffer different refractions: the difference possibly varying with the time of year.

But the immediate object of the present note is to point out that the *R—D* discordance is subject to an annual fluctuation, whatever the cause. For this purpose little more is necessary than to print the following table of results, obtained as follows:—The whole of the observations 1883–1890 were collected and divided into groups according to the month of the year, retaining the cross grouping in zenith-distance; in fact, the subdivision into twelve months is merely substituted for that into eight years, so that we have in each monthly group about two-thirds of the number of stars formerly found in each annual group, and the material for determining the *R—D* for any month is comparable with that usually employed for the annual determination. In one or two cases where there was no star in a particular group, a mean value for that group has been adopted from neighbouring groups, and the result enclosed within brackets.

Mean R-D Discordance for each Calendar Month in the Years 1883-1890.

North Stars.

Mean N.P.D. of Group.	Mean Z.D. of Group.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
-29°0'	-67°30'	+0°06	-0°94	-1°04	-1°67	-0°75	-1°06	-1°56	-0°80	-0°38	-0°57	-0°23	-0°44
-27°0	-65°30	-0°97	-0°90	-1°38	-1°24	-1°11	-1°03	-0°96	-0°73	-3°43	-0°77	-0°54	-0°58
-25°0	-63°30	-1°63	-1°55	-1°11	-1°20	-2°22	-2°15	-1°22	-1°45	-1°03	-1°04	-1°35	-1°05
-23°0	-61°30	(-1°62)	-0°90	-1°27	-1°82	-1°30	-1°79	-1°67	-1°23	-0°47	-1°02	-0°86	+1°31
-20°30	-59°0	-1°60	-1°89	-1°82	-1°75	-2°03	-1°87	-0°89	-0°93	-1°11	-1°67	-1°48	-1°67
-17°0	-55°30	-1°58	-0°38	-0°64	-1°27	-1°38	-1°45	-1°47	-1°16	-1°01	-1°53	-1°04	-1°24
-13°0	-51°30	-0°52	-1°12	+1°35	-1°01	-0°44	-1°03	-1°28	-0°45	-0°91	-1°01	-0°48	-1°09
-8°30	-47°0	-1°50	-1°08	-1°02	-1°29	-1°57	-0°80	-1°81	-0°73	-0°63	-0°96	-0°61	-0°66
-3°0	-41°30	+0°01	-0°22	-0°88	-0°12	-0°35	-0°77	-0°54	-0°53	-0°42	-0°46	-0°58	-0°48
+3°0	-35°30	-0°11	-0°38	-0°01	-1°53	-0°57	-0°92	-0°76	-0°94	-0°69	-0°40	-0°52	-0°86
+8°30	-30°0	-0°09	-0°51	-0°45	-0°29	-0°78	-0°47	-0°36	-0°72	-0°43	-0°50	-0°46	-0°85
+14°0	-24°30	-0°68	+0°19	+0°07	-0°46	-1°01	-0°65	-0°51	-0°33	-0°75	-0°88	-0°56	-0°36
+18°30	-20°0	-0°78	+0°28	+0°37	-0°76	-1°38	-1°12	-0°87	-0°54	-0°59	+0°15	-0°68	-0°30
+22°0	-16°30	+0°63	+0°47	-0°44	-0°62	-0°39	-0°55	-0°45	-0°47	-0°13	-0°46	-1°04	-0°03
+25°0	-13°30	-0°53	+0°19	-0°12	-0°04	-0°47	-0°73	-0°14	+0°45	-0°06	+0°31	-0°45	-0°68
+33°0	-5°30	-0°48	+0°84	+0°15	-0°12	-0°48	-0°33	+1°95	-0°09	-0°04	+0°20	+0°36	+0°41

South Stars.

Mean N.P.D. of Group.	Mean Z.D. of Group.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
+ 46'0	+ 7'30	+ 0'52	+ 0'71	+ 0'54	+ 2'72	+ 0'34	+ 0'99	+ 0'66	+ 0'22	+ 0'79	+ 0'23	+ 0'38	+ 0'51
+ 57'0	+ 18'30	+ 0'42	+ 1'04	+ 0'78	+ 0'52	+ 0'17	+ 0'30	+ 0'78	+ 0'30	+ 0'49	+ 0'22	+ 0'23	+ 1'17
+ 62'30	+ 24'0	+ 0'27	+ 0'95	+ 0'47	+ 0'03	+ 0'05	+ 0'84	+ 0'49	+ 0'37	+ 0'46	+ 0'59	+ 0'05	+ 0'31
+ 65'30	+ 27'0	+ 0'67	+ 0'12	+ 0'06	+ 0'41	+ 0'50	+ 0'16	+ 0'57	+ 0'08	+ 0'09	+ 0'48	+ 0'20	+ 0'01
+ 68'30	+ 30'0	+ 0'44	+ 0'12	+ 0'11	+ 0'69	+ 0'32	+ 0'91	+ 0'49	+ 0'35	+ 0'25	+ 0'98	+ 0'10	+ 0'13
+ 72'0	+ 33'30	+ 0'34	+ 0'32	+ 0'18	+ 0'58	+ 0'19	+ 0'37	+ 0'11	+ 0'31	+ 0'13	+ 0'36	+ 0'48	+ 0'27
+ 76'0	+ 37'30	+ 1'42	+ 0'06	+ 0'07	+ 0'16	+ 0'69	+ 0'52	+ 0'57	+ 0'42	+ 0'54	+ 0'05	+ 0'23	+ 0'19
+ 81'0	+ 42'30	+ 0'20	+ 0'19	+ 0'29	+ 0'66	+ 0'46	+ 0'94	+ 1'12	+ 0'61	+ 0'53	+ 0'41	+ 0'73	+ 0'41
+ 86'0	+ 47'30	+ 0'42	+ 0'71	+ 0'96	+ 0'97	+ 1'29	+ 0'73	+ 1'04	+ 0'37	+ 0'44	+ 0'72	+ 1'28	+ 1'41
+ 90'0	+ 51'30	+ 0'75	+ 0'77	+ 0'52	+ 1'09	+ 1'39	+ 0'78	+ 0'98	+ 1'54	+ 0'87	+ 1'01	+ 0'87	+ 0'56
+ 94'0	+ 55'30	+ 0'25	+ 0'98	+ 0'55	+ 0'74	+ 0'95	+ 1'97	+ 1'45	+ 1'23	+ 1'07	+ 1'95	+ 1'13	+ 0'96
+ 97'30	+ 59'0	+ 0'22	+ 0'83	+ 1'64	+ 1'51	+ 1'38	+ 1'14	+ 1'35	+ 0'66	+ 0'64	+ 1'62	+ 1'39	+ 2'44
+ 100'15	+ 61'45	+ 0'47	+ 1'14	+ 0'86	+ 1'59	+ 1'30	+ 1'53	+ 1'32	+ 1'72	+ 1'08	+ 1'46	+ 0'61	+ 1'44
+ 103'15	+ 64'45	+ 0'02	+ 1'42	+ 1'53	+ 1'82	+ 1'98	+ 1'53	+ 1'23	+ 1'15	+ 1'05	+ 0'09	+ 0'76	(+ 0'63)
+ 107'0	+ 66'30	+ 1'83	+ 2'19	+ 1'95	+ 1'99	+ 2'12	+ 2'40	+ 2'26	+ 1'63	+ 1'54	+ 1'15	+ 1'34	+ 0'17

If we assume the expression $a + b \sin Z. D.$ for the discordance, and determine by least squares the values of a and b for each month, we obtain the following values:—

	a	b
January ...	—0'01	+0''97
February ...	—0'01	+0'93
March ...	—0'01	+1'13
April ...	—0'04	+1'29
May ...	—0'11	+1'49
June ...	—0'09	+1'47
July ...	—0'07	+1'37
August ...	—0'06	+1'22
September ...	—0'04	+1'14
October ...	—0'06	+1'12
November ...	0'00	+1'09
December ...	—0'04	+0'99

Showing a well-marked inequality in b of 0''·6. The cause of this inequality is at present the subject of further investigation.

The Apparent Places of Close Polar Stars.

By A. M. W. Downing, M.A.

In the *Monthly Notices*, vol. l., pp. 357–359, Mr. Turner calls attention to certain discordances in the apparent places of polars, as given in the different Ephemerides for 1891 and some preceding years. As modifications have been introduced both into the *Connaissance des Temps* and into the *Nautical Almanac* since the publication of Mr. Turner's note, I have thought that it would be worth while communicating to the Society the results of comparisons of the apparent right ascensions of *Polaris*, λ *Ursæ Minoris*, and σ *Octantis*, as given in the *Connaissance des Temps* and *Nautical Almanac* for 1894, as well as of the apparent right ascensions of the two first-named stars as given in the *Berliner Jahrbuch* and in the *American Ephemeris*, with those of the *Nautical Almanac* for the same year. As the *Berliner Jahrbuch* for 1894 had not reached me when this work was undertaken, the method of procedure followed was to compare the places in the *Berliner Jahrbuch* for 1893 with those of the *Connaissance des Temps* for the same year, and from the results of the comparison of the places in the latter publication with those of the *Nautical Almanac* for 1894 to deduce the differences of places of the *Berliner Jahrbuch* and of the *Nautical Almanac*. It may be remarked that no change was

made, either in the *Connaissance des Temps* or the *Berliner Jahrbuch*, in the adopted methods of computing apparent places of polars in 1894, so that the results obtained from a comparison of the places for 1893 may be assumed to hold good for 1894 also. In all these comparisons the effect of difference of longitude of the meridians for which the computations of the different Ephemerides were made has been taken into account.

In 1894 an important modification was introduced into the *Nautical Almanac*—viz., terms of the second order in the “star-corrections” have been taken into account in the cases of the close polar stars by the method proposed by Fabritius (*Ast. Nachrichten*, Nos. 2072 and 2073), the form adopted being the very convenient one given by Oppolzer in his *Traité de la détermination des Orbites*, p. 264:—

$$\alpha - \alpha_0 = \Delta\alpha_0 + \tan \delta_0 \Delta\alpha_0 \Delta\delta_0 \sin 1'',$$

$$\delta - \delta_0 = \Delta\delta_0 - \frac{1}{2} \cot \delta_0 \Delta\alpha_0^2 \sin 1'',$$

where α_0 , δ_0 are the mean values of the coordinates for the beginning of the year. This method is also adopted in the *Connaissance des Temps*, and the same terms of nutation being used in it and in the *Nautical Almanac*, the agreement between the “star-corrections” for polars ought now to be very close, as in fact it will be seen to be by reference to the tables of comparisons given below. The difference in the adopted value of the precession constant gives rise principally, of course, to a discordance proportional to the time (as does also a difference in the adopted proper motion), and is well marked in the case of the places of *Polaris*.

In both the *Berliner Jahrbuch* and the *American Ephemeris* the corrections due to the effect of the terms of a higher order than the first are computed from the ordinary formulæ, somewhat similar expressions being used in both publications. In the *Berliner Jahrbuch* the same terms of nutation are employed as in the *Connaissance des Temps* and *Nautical Almanac*; whilst in the *American Ephemeris* several additional terms are taken into account.

Most of these have very small coefficients, and in the present state of astronomy may perhaps be safely neglected. One pair of terms, however, with argument $(2\odot - \Omega)$, seem to make their effect very sensible in the comparison between the *Nautical Almanac* and the *American Ephemeris*, giving rise to an inequality with period of about six months, which is apparent both in the case of *Polaris* and in that of λ *Ursæ Minoris*. The terms in question are—

$$\text{In obliquity} \quad -''0067 \cos (2\odot - \Omega);$$

$$\text{In longitude} \quad +''0125 \sin (2\odot - \Omega);$$

and these might perhaps be introduced into the expressions for

the "Day Numbers" in the other Ephemerides also with advantage.

The tables given below require very little explanation. A "group" is the mean of ten days (except, of course, Group xxxvii.), and the differences are the actual differences corrected only for longitude, where this correction is sensible. These mean differences have been plotted down, and curves drawn, where it appeared necessary, to guide the eye in estimating the periodic discordances. The agreement between the *Connaissance des Temps* and the *Nautical Almanac* is practically complete, the greatest discordance—viz. $0^s.05$ for λ *Ursæ Minoris*—being in arc of a great circle $\frac{05 \times 15}{56}$, or $0''.01$. The periodic discordances

between the *Berliner Jahrbuch* and the *Nautical Almanac* (which seem to be clearly enough indicated, although the quantities are so small) may be due to difference in the method of correcting for second order terms, for, as stated above, the same terms of nutation (as well as the same constant of precession) are employed in the computations in each case. The discordances existing between the *American Ephemeris* and the *Nautical Almanac* may be partly due to the same cause, but in their more marked features they are probably to be ascribed to the effect of the additional terms of nutation adopted in the *American Ephemeris*, which have been referred to above.

The amount of Fabritius' correction for *Polaris* and λ *Ursæ Minoris* is also exhibited graphically for every tenth day throughout the year 1894, in order to enable the reader to form an estimate of its magnitude and variation during the course of a year. It will be remarked that, although the horizontal scale is the same, the vertical scale in this case is only one-tenth of what it is in the comparisons of the stars' right ascensions.

Generally, the close agreement of the "star-corrections" for these polars, as given in the different Ephemerides, will be remarked, as well as the great improvement that has taken place in this respect during the last few years.

Right Ascensions of Polaris.

Group.	N. A.—C. T. 1894. s	N. A.—E. 1894. s	C. T.—B. J. 1893. s
I.	+ 0'049	— 1'398	— 1'167
II.	+ 0'059	— 1'396	— 1'178
III.	+ 0'064	— 1'390	— 1'183
IV.	+ 0'067	— 1'407	— 1'182
V.	+ 0'070	— 1'432	— 1'180
VI.	+ 0'071	— 1'438	— 1'170
VII.	+ 0'079	— 1'455	— 1'168
VIII.	+ 0'080	— 1'443	— 1'156
IX.	+ 0'082	— 1'433	— 1'145

Group.	N. A. - C. T. 1894. ■	N. A. - A. E. 1894. s	C. T. - B. J. 1893. s
X.	+ 0°081	- 1°446	- 1°154
XI.	+ 0°085	- 1°425	- 1°163
XII.	+ 0°090	- 1°407	- 1°149
XIII.	+ 0°092	- 1°406	- 1°145
XIV.	+ 0°089	- 1°406	- 1°140
XV.	+ 0°092	- 1°400	- 1°154
XVI.	+ 0°093	- 1°370	- 1°154
XVII.	+ 0°095	- 1°381	- 1°138
XVIII.	+ 0°095	- 1°398	- 1°151
XIX.	+ 0°097	- 1°397	- 1°166
XX.	+ 0°093	- 1°390	- 1°144
XXI.	+ 0°095	- 1°389	- 1°147
XXII.	+ 0°095	- 1°381	- 1°166
XXIII.	+ 0°098	- 1°416	- 1°157
XXIV.	+ 0°100	- 1°420	- 1°162
XXV.	+ 0°100	- 1°415	- 1°163
XXVI.	+ 0°100	- 1°424	- 1°171
XXVII.	+ 0°101	- 1°427	- 1°183
XXVIII.	+ 0°100	- 1°400	- 1°173
XXIX.	+ 0°104	- 1°402	- 1°184
XXX.	+ 0°101	- 1°407	- 1°205
XXXI.	+ 0°104	- 1°414	- 1°190
XXXII.	+ 0°106	- 1°394	- 1°195
XXXIII.	+ 0°110	- 1°384	- 1°209
XXXIV.	+ 0°103	- 1°391	- 1°206
XXXV.	+ 0°108	- 1°405	- 1°208
XXXVI.	+ 0°108	- 1°403	- 1°216
XXXVII.	+ 0°110	- 1°405	- 1°225

Right Ascensions of λ Ursæ Minoris.

I.	- 0°564	- 1°032	+ 0°309
II.	- 0°567	- 1°042	+ 0°328
III.	- 0°566	- 1°015	+ 0°331
IV.	- 0°563	- 1°020	+ 0°319
V.	- 0°562	- 1°011	+ 0°319
VI.	- 0°569	- 1°027	+ 0°303
VII.	- 0°574	- 1°030	+ 0°303
VIII.	- 0°575	- 1°034	+ 0°295
IX.	- 0°576	- 1°041	+ 0°278

Group.	N. A.—C. T. 1894. ^s	N.A.—A. E. 1894. ^s	C. T.—B. J. 1893. ^s
X.	—0°577	—1°056	+0°281
XI.	—0°581	—1°041	+0°287
XII.	—0°584	—1°055	+0°275
XIII.	—0°589	—1°043	+0°274
XIV.	—0°592	—1°011	+0°292
XV.	—0°588	—1°012	+0°308
XVI.	—0°59	—1°012	+0°298
XVII.	—0°595	—1°010	+0°292
XVIII.	—0°597	—1°015	+0°311
XIX.	—0°602	—1°003	+0°327
XX.	—0°604	—1°032	+0°303
XXI.	—0°608	—1°038	+0°317
XXII.	—0°610	—1°032	+0°334
XXIII.	—0°599	—1°045	+0°329
XXIV.	—0°601	—1°040	+0°328
XXV.	—0°597	—1°020	+0°344
XXVI.	—0°597	—1°031	+0°350
XXVII.	—0°597	—1°018	+0°350
XXVIII.	—0°594	—1°000	+0°343
XXIX.	—0°594	—1°011	+0°345
XXX.	—0°586	—0°986	+0°353
XXXI.	—0°582	—0°986	+0°328
XXXII.	—0°584	—0°974	+0°315
XXXIII.	—0°576	—0°953	+0°341
XXXIV.	—0°577	—0°992	+0°317
XXXV.	—0°577	—0°979	+0°306
XXXVI.	—0°572	—0°975	+0°310
XXXVII.	—0°565	—1°007	+0°320

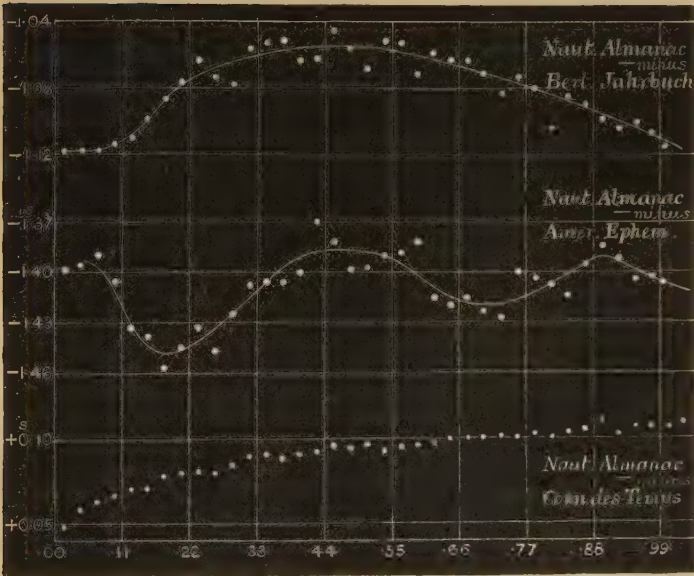
Right Ascensions of σ Octantis.

Group.	N. A.—C. T. 1894. ^s	Group.	N. A.—C. T. 1894. ^s
I.	+0°133	VIII.	+0°136
II.	+0°124	IX.	+0°133
III.	+0°121	X.	+0°130
IV.	+0°127	XI.	+0°128
V.	+0°134	XII.	+0°137
VI.	+0°134	XIII.	+0°134
VII.	+0°126	XIV.	+0°124

Group.	N. A. - C. T. 1894. s	Group.	N. A. - C. T. 1894. s
XV.	+0°126	XXVII.	+0°131
XVI.	+0°129	XXVIII.	+0°134
XVII.	+0°124	XXIX.	+0°135
XVIII.	+0°123	XXX.	+0°137
XIX.	+0°130	XXXI.	+0°140
XX.	+0°133	XXXII.	+0°142
XXI.	+0°122	XXXIII.	+0°145
XXII.	+0°127	XXXIV.	+0°143
XXIII.	+0°132	XXXV.	+0°152
XXIV.	+0°137	XXXVI.	+0°148
XXV.	+0°129	XXXVII.	+0°158
XXVI.	+0°130		

RIGHT ASCENSIONS OF POLARIS.

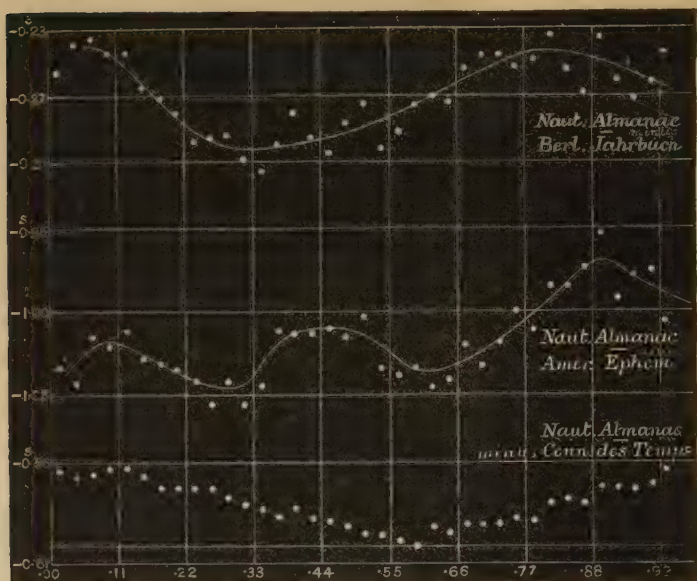
$\delta = 88^{\circ} 45'$, sec $\delta = 45.8$.



The horizontal scale is fraction of the year.

RIGHT ASCENSIONS OF λ URSE MINORIS.

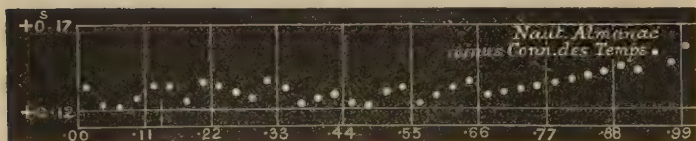
$$\delta = 88^\circ 59', \sec \delta = 56.4.$$



The horizontal scale is fraction of the year.

RIGHT ASCENSIONS OF σ OCTANTIS.

$$\delta = 89^\circ 16', \sec \delta = 78.1.$$

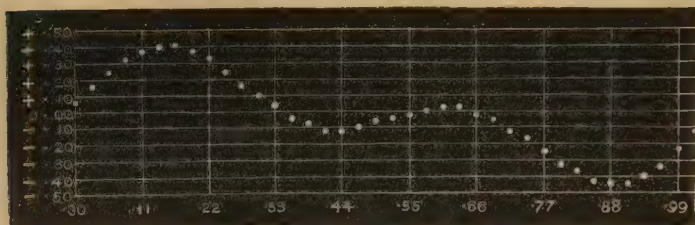


The horizontal scale is fraction of the year.

FABRITIUS' CORRECTION FOR POLARIS (R.A.) 1894.



The horizontal scale is fraction of the year.

FABRITIUS' CORRECTION FOR λ URSAE MINORIS (R.A.) 1894.

The horizontal scale is fraction of the year.

Nautical Almanac Office :
1892 March 8.

Results of Double-Star Measures with the 8-inch Equatoreal at Windsor, N. S. Wales, in 1891. By J. Tebbutt.

Ref. No.	Star.	Observed Magnitude.	Approx. Place of Star. R. A. h m	Dec. S. s' s"	Fraction of Year.	Position of Angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour-Angles. h m	Weight, 1 to 5.
1	p Eridani	6, 6	1 36	56 45	'739	...	...	7'30	10	170	2 30 E 2 15 E	5
2	"	6, 6	"	"	'745	225'2	10	...	...	300	2 51 E 2 37 E	5
3	"	...	"	"	'750	225'6	10	...	...	300	3 43 E 3 31 E	3
4	"	6, 6	"	"	'758	225'6	10	...	...	...	2 37 E 2 21 E	5
5	"	6, 6	"	"	'758	...	...	7'03	10	...	2 4 E 1 47 E	5
6	"	...	"	"	'805	...	...	7'08	10	170	3 44 E 3 26 E	3
7	"	...	"	"	'991	227'9	10	...	...	230	2 19 W 2 40 W	3
8	"	...	"	"	'991	...	...	7'63	7	170	2 44 W 2 58 W	3
9	Lalande, 4219	8, 8	2 11	18 44	'745	335'6	10	...	...	300	2 32 E 2 20 E	4
10	"	8, 8	"	"	'745	337'2	10	...	...	230	2 20 E 2 5 E	4
11	α Centauri	...	14 32	60 23	'515	205'8	10	...	...	300	2 56 E 2 43 E	4
12	"	...	"	"	'559	207'6	10	...	...	230	0 52 W 1 9 W	2
13	"	...	"	"	'561	205'9	10	...	...	230	2 29 E 2 20 E	4
14	"	...	"	"	'561	...	...	19'10	10	170	1 51 E 1 34 E	3
15	"	...	"	"	'583	...	...	19'40	10	170	1 0 E 0 40 E	2
16	"	...	"	"	'583	205'4	10	...	...	300	0 36 E 0 0	3
17	"	...	"	"	'613	205'0	10	...	...	230	0 47 E 0 38 E	3
18	"	...	"	"	'613	...	...	18'91	10	170	0 38 E 0 14 E	3
19	"	...	"	"	'616	...	...	19'09	10	170	0 25 E 0 12 E	3
20	"	...	"	"	'635	207'5	10	...	...	300	4 8 W 4 22 W	3

Ref. No.	Star.	Observed Magnitude.	Approx. Place of Star. R. A. h m	Fraction of Year.	Position of Angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour-Angles. h m	Weight, 1 to 5.
21	α Centauri	...	14 32	.646	206.1	10	...	...	500	3 2 W 3 25 W	4
22	"	...	"	.646	...	...	19.85	6	170	3 31 W 3 52 W	3
23	"	...	"	.654	...	...	19.41	10	170	1 35 W 2 3 W	2
24	"	...	"	.657	...	...	19.43	10	170	1 34 W 1 54 W	3
25	"	...	"	.657	...	...	19.61	5	170	2 47 W 2 57 W	4
26	"	...	"	.663	...	...	19.23	5	170	1 25 E 1 7 E	3
27	"	...	"	.663	...	...	19.24	10	170	0 3 W 0 14 W	4
28	39 Ophiuchi	6, 8	17 11	.695	...	...	10.57	5	170	3 21 W 3 36 W	...
29	"	...	"	.726	...	...	10.53	7	170	2 45 W 2 59 W	...
30	"	...	"	.726	354.9	10	...	...	300	3 21 W 3 43 W	...
31	"	...	"	.739	353.8	10	...	...	140	2 40 W 2 51 W	5
32	κ Cor. Aust.	6, 7	18 26	.758	358.3	6	...	...	...	3 29 W 3 39 W	5
33	Brisb. 6556	...	18 54	.635	277.4	10	...	...	140	0 39 E 0 28 E	5
34	"	...	"	.638	280.5	10	...	...	230	1 6 E 0 28 E	4
35	"	7, 7	"	.745	...	...	10.15	8	170	2 15 W 2 39 W	5
36	"	7, 7	"	.745	280.6	10	...	...	300	3 22 W 3 36 W	5
37	"	...	"	.747	281.4	10	...	...	300	1 52 W 2 5 W	5
38	"	...	"	.750	280.8	10	...	...	300	1 44 W 1 57 W	3
39	h 5075	8, 8	18 54	.758	110.5	10	...	...	300	3 28 W 3 51 W	4
40	γ Cor. Aust.	...	18 59	.635	...	...	1.57	10	170	3 7 E 1 52 E	4
41	"	...	"	.635	180.1	10	...	...	300	1 36 E 1 17 E	4

Ref. No.	Star.	Observed Magnitude.	Approx. Place of Star. R. A. h m	Dec. S. ° '	Fraction of Year.	Position of Angle.	No. of Obs.	Distance. "	No. of Obs.	M. g. Power.	Hour-Angles. h m	h m	Weight, 1 to 5.
42	γ Cor. Aust.	...	18 59	37 13	.638	178.1	10	...	...	300	1 34 E	1 6 E	3
43	"	...	"	"	.643	177.3	10	...	...	300	1 44 E	1 24 E	5
44	"	6, 6	"	"	.739	174.7	10	...	...	300	1 42 W	1 54 W	5
45	"	6, 6	"	"	.739	...	...	1.48	10	170	2 26 W	2 38 W	5
46	"	...	"	"	.742	...	...	1.57	6	170	1 28 W	1 37 W	3
47	"	6, 6	"	"	.745	...	...	1.52	10	170	2 0 W	2 15 W	5
48	"	6, 6	"	"	.745	174.5	10	...	...	300	2 40 W	2 59 W	5
49	"	6, 6	"	"	.745	175.0	10	...	...	300	3 1 W	3 12 W	5
50	"	...	"	"	.747	175.3	10	...	...	300	1 29 W	1 42 W	5
51	"	...	"	"	.750	176.3	10	...	...	300	1 54 W	2 3 W	4
52	"	6, 6	"	"	.758	175.7	10	...	...	...	2 32 W	2 47 W	5

Remarks.

Nos. 1, 2, 4, 5, 6, 9, 10, 21, 22, 26, 27, 31, 33, 34, 39, 40, 43, 44, 45, 46, 47, 48, 49, 50, 52. The line joining the observer's eyes was parallel to that joining the components.

Nos. 1, 4, 5, 34, 44, 45, 47, 48, 49, 52. Components equal.

Nos. 7, 8. The driving clock acted badly, and the measures were difficult.

Nos. 11, 13, 14, 15, 16, 17, 18, 19, 26, 27. Observations during sunlight.

No. 28. Large star pale red and companion pale blue.

Nos. 28, 29. Direct distances deduced from observed differences of declination and an assumed position-angle.

No. 33. Components equal and bluish.

No. 39. The preceding component probably the brighter.

Nos. 9, 10. South component slightly the brighter.

Nos. 23, 24. Observations in twilight.

Nos. 35, 36. The following star probably the brighter.

Windsor, N. S. Wales :

1892 January 22,

*Maxima and Minima of Variable Stars Observed during the Years
1889, 1890, and 1891. By John Mitchell.*

The following results have been derived from observations made with an achromatic of 3·5 inches aperture, using constantly an eyepiece of low power.

The mode of observation has been to compare the variable with stars differing little from it in brightness, and whose magnitudes had been kindly supplied to me by Mr. Baxendell, who, I believe, determined some of them himself, and obtained the remainder from his late father and the late Mr. Pogson.

R Cygni.

Maximum: 1889 Oct. 9; mag. 7·1

S Ursæ Majoris.

Maximum: 1889 Sept. 15; mag. 7·6

Minimum: 1890 Jan. 1; „ 12·35

Maximum: 1890 Apr. 18; „ 7·6

Minimum: 1890 Aug. 20; „ 12·25

Minimum: 1891 Apr. 2 ±; „ ?

Maximum: 1891 July 13; „ 7·75

Minimum: 1891 Nov. 10; „ 12·45

T Ursæ Majoris.

Maximum: 1890 June 3; mag. 7·1

Maximum: 1891 Nov. 1; „ 7·85

Observations have been made as follows:—

	<i>R Cygni.</i>	<i>U Geminorum.</i>	<i>S Ursæ Majoris.</i>	<i>T Ursæ Majoris.</i>
In 1889	30 nights.	...	26 nights.	13 nights.
„ 1890	26 „	...	40 „	31 „
„ 1891	30 „	12 nights.	58 „	42 „

Brockholes, Huddersfield:
1892 February 25.

Occultation of γ_1 and γ_2 Virginis. By the Rev. A. Freeman.

The disappearances of these stars took place January 19, 1892, a little east of the south point of the bright limb of the Moon. The star γ_1 Virginis disappeared at $16^h 2^m 53^s.8$, G.M.T., the star γ_2 at $16^h 3^m 12^s.3$. Dense cloud unfortunately prevented the observation of the reappearances at the dark limb about one hour later. I employed a $6\frac{1}{2}$ -inch O.G. with a power of 90. Each star took from 2.5 to 3 seconds, after projection within the limb of the Moon as a bright round point, before it finally disappeared; a separate less bright segment of a star was in each case seen just outside the limb. The times recorded refer to the disappearances of these segments, which were simultaneous with those of the projected stars. I consider that, in this case, the apparent effect of projection was due to the fact that perfect achromatism is impossible with an object-glass composed of two lenses only. The principal rays of light collected by the object-glass in a common focus give the bright star image as seen apparently within the limb, but the apparent diameter of the Moon is enlarged by imperfect achromatism, and the segments of stars are parts of uncorrected images out of focus. The line joining the two stars seemed to the eye inclined about 25° from the normal to the Moon's limb, γ_2 being east of the normal at the disappearance of γ_1 . From the Greenwich Ten-Year Catalogue for 1880 I find the mean places of the stars for 1892.0 would be:—

		^h	^m	^s		[°]	[']	["]
γ_1 Virg.	R.A.	12	36	11.122,	S.D.	0	51	22.73
γ_2 Virg.	R.A.	12	36	11.296,	S.D.	0	51	28.10

Annual precession, secular variation, and proper motion are the same for both stars. Hence the position angle of γ_2 , referred to γ_1 , would seem to be $154^\circ 4'.75$, and its distance $5''.97$. I judged γ_1 to be the brighter of the two stars. The approximate position of my observatory is in lat. $51^\circ 20' N.$, long. $3^m 0^s E.$

Murston Rectory, Sittingbourne:
1892 March 7.

The Reappearance of Saturn's Rings. By George C. Comstock.

(Communicated by H. H. Turner, M.A., B.Sc.)

The communication respecting the reappearance of *Saturn's* rings made to the Royal Astronomical Society by the Rev. A. Freeman, M.A., and published in the *Monthly Notices* for November 1891, makes it proper that I should publish through the same channel the results of observations of *Saturn* made at this observatory, although a brief account of some of them has already appeared in the *Sidereal Messenger* for November.

At my request Mr. S. D. Townley, assistant in the observatory, commenced about the middle of October an examination of *Saturn* on every clear morning, using the Clark equatoreal of 40 cm. aperture with the so-called zone eyepiece, giving a power of 145 diameters. On a few mornings I myself took part in the observations, which is indicated in the following extracts from Mr. Townley's note-book, by the letter *C*, prefixed to those parts of the observing for which I am personally responsible. The remaining, and by far the greater number of, observations are by Mr. Townley. The times are given in mean solar time of the meridian 90° west of Greenwich, and the dates in civil reckoning.

1891 October 16.—Rings not visible. The shadow of the rings on the ball is seen plainly. Also belts on each side and parallel to the shadow; south belt plainer. The shadow of the rings appears to divide the ball into two unequal parts, of which the southern (?) part is the larger. Seeing good. *C*. confirms the above description.

October 20, 4^h 50^m.—Rings not visible, but seeing is not very good. 5^h 24^m. Seeing better than before. Rings visible, but most plainly in preceding limb. *C*. Mr. Townley called me to the telescope, saying that he could see the rings. The ansæ are visible with difficulty, but certainly on both sides of the planet; more plainly on the pr. side. Ansæ project beyond the ball—two-thirds of the diameter of the planet.

At 5^h 45^m made sketch of *Saturn* with power of 310 diameters, with approximate location of the satellites visible near the ball. These were subsequently identified from Marth's ephemeris. At the time of the sketch, Rhea could just be distinguished at its reappearance from behind the ball of the planet. A measurement from the sketch places it 4''·1 south of the planet's equator at the time of reappearance.

October 22, 4^h 30^m.—Rings not visible. Seeing very bad. 4^h 50^m. Seeing is not much improved. Thought once that I caught a glimpse of the rings on the following side. 5^h 30^m. No rings visible, but daylight too far advanced for the best seeing. *C*. No rings visible at 4^h 45^m and 5^h 55^m.

October 25, 5^h 10^m.—Rings visible by glimpses, extending on both sides of planet to distances of 0·6 or 0·7 of the planet's diameter.

5^h 30^m.—Same as above, with power of 145; but could not see rings with power of 310. Images very steady, but faint, on account of heavy fog which envelopes the observatory.

October 26, 5^h 15^m.—Rings visible by glimpses. Seeing so bad that I cannot see the markings on the planet's surface.

October 27, 5^h 15^m.—Same as October 26.

October 31, 5^h 15^m.—Rings plainly visible as continuous lines, extending on each side to a distance of about 0·6 the diameter of the ball. Tried power of 310, but could see nothing. Seeing rather bad. Images diffuse and unsteady.

November 5, 5^h 20^m.—Rings very plainly visible, extending on each side 0·5 the diameter of the ball. Seeing not good.

The above observations, made with superior optical appliances, are entirely inconsistent with Mr. Freeman's conclusion "that the plane of *Saturn's* rings probably passed through the Sun's centre on November 1, at about 6 A.M., or possibly one hour, or two hours at most, earlier"; and it is a matter of surprise that he should not have detected the ansæ on October 30 and 31, since the difference between the apertures of his telescope and the one employed at Madison cannot well explain a difference of ten days in the date of reappearance of the ring.

In one respect, however, I wish to confirm Mr. Freeman's observations. My sketch of October 20, above referred to, shows the broad band across *Saturn's* disc wholly south of the equator, and its southern edge *very slightly curved*, with convexity southwards.

Washburn Observatory:
1892 January 1.

Ephemerides of the Satellites of Saturn, 1891-92. By A. Marth. (Concluded.)

The following list of phenomena is a continuation of that published to the end of April, on p. 195. From the middle of April to the end of June the planetocentric latitude of the Earth above the plane of *Saturn's* equator is less than 1°, and the apparent orbits of the satellites are very narrow ellipses, so that the distances of the satellites at the times of their conjunctions are very small. I have therefore considered it worth while to make a search for the conjunctions which occur during the indicated period and are observable in America or Europe, and to insert them in the list, in the hope that favoured observers will duly attend to these rare and interesting test-phenomena, and will measure the differences of the rectangular coordinates parallel to the axes of the planet's disc, or in the position-angles.

P and $P \pm 90^\circ$. In order to compress the indications of the conjunctions, the usual sign $\circ$ has been omitted, the initials of the satellites being placed in line (the quicker-moving first), with the letters *n.* or *s.* (north or south) attached, and followed by the approximate value (expressed in semi-diameters of the planet's equator) of the distance of the satellites from the polar axis of the disc.

As the shadows of Rh., Di., Te. are reported to be discernible, the approximate times of "Sh.," their crossing the central meridian, are inserted. The phenomena for April supplement those already published on p. 194.

G.M.T. 1892.	h	
Apr. 10	13.2	Di. Sh.
	15.9	Te. Sh.
	19.8	Rh. Sh.
11	8.2	Rh. s. Di. n. - 6.1
	16.6	En. s. Te. n. + 1.5
12	13.2	Te. Sh.
	17.7	Rh. n. Titan s. - 3.8
	18.5	Te. s. Rh. n. - 3.4
13	6.9	Di. Sh.
	9.2	Te. n. Di. s. - 1.7
	13.3	Di. s. En. n. - 3.9
14	10.6	Te. Sh.
	12.7	Te. s. Di. n. - 1.6
15	8.2	Rh. Sh.
	15.0	Te. n. En. s. + 3.7
16	7.9	Te. Sh.
	10.8	Te. s. En. n. - 2.1
18	18.3	Di. Sh.
19	11.1	Rh. s. Te. n. + 4.3
	12.9	Rh. s. En. n. + 3.5
	20.7	Rh. Sh.
20	8.9	Te. s. En. n. - 4.0
	20.2	En. n. Titan n. + 2.7
21	12.0	Di. Sh.
22	10.0	Rh. n. En. s. + 4.0
	10.9	Di. n. Te. - 5.0
23	15.4	Te. s. En. n. + 3.4
	21.1	Te. Sh.
24	9.1	Rh. Sh.
	12.0	Di. s. En. n. - 3.9
	14.4	Rh. s. En. n. - 3.1
	14.5	Rh. s. Te. n. - 3.2
	14-16.6	En. closely pursued but not overtaken by Te.
25	16.2	Di. Ecl. R.
	16.2	Te. s. Di. n. + 1.3
	18.4	Te. Sh.
26	13.4	Di. Sh.
27	15.8	Te. Sh.
28	10.7	Te. n. Titan s. - 2.2
	13.7	Di. n. Rh. s. + 3.5
	15.3	Titan s. En. n. - 3.8
	21.6	Rh. Sh.
29	13.1	Te. Sh.
	17.1	Di. Sh.

G.M.T. 1892.	h	
May 1	7.3	Rh. ϵ
	8.5	Te. β
	10.4	Te. Sh.
	11.4	Te. γ
	12.2	En. θ
	12.4	Mi. ϵ
	12.8	En. n. Te. s. - 1.9
	13.4	Te. η
	16.3	Rh. n. Di. n. + 6.3
	17.1	Mi. ζ
	18.6	En. ϵ
2	8.5	Di. β
	10.5	Te. Ecl. R.
	10.8	Di. Sh.
	11.0	En. η
	11.0	Mi. ϵ
	11.8	Di. γ
	12.1	Te. ϵ
	14.0	Di. η
	16.4	Mi. ζ
3	7.0	Rh. β
	7.7	Te. Sh.
	8.7	Te. γ
	9.6	Mi. ϵ
	10.1	Rh. Sh.
	10.7	Te. η
	10.9	Rh. γ
	12.9	Te. s. Di. n. - 3.5
	13.5	Rh. η
	13.6	En. ζ
	15.0	Mi. ζ
	15.1	Di. θ
	17.4	Di. δ
4	7.9	Te. Ecl. R.
	8.3	Mi. ϵ
	9.4	Te. ϵ
	12.4	En. ϵ
	13.7	Mi. ζ
5	7.7	Di. η
	8.0	Te. η
	9.1	Di. s. Rh. n. - 3.1
	9.2	Te. s. Rh. n. - 3.0
	10.7	Rh. θ
	10.8	Di. s. En. n. - 4.0
	11.1	Te. s. En. n. - 3.9

G.M.T. 1892.		h	
May	5	12.3	Mi. ζ
		13.2	Rh. δ
		14.9	En. θ
		18.1	Rh. Ecl. R.
		18.2	Mi. η
		19.7	Rh. ϵ
	6	7.3	Titan δ
		7.3	En. ζ
		8.8	Di. θ
		10.9	Mi. ζ
		11.0	Di. δ
		13.2	Titan α
		13.7	En. η
		15.0	Di. Ecl. R.
		15.7	Di. n . Titan n . + 1.9
		16.5	Di. ϵ
		16.8	Mi. η
		17.1	Titan ϵ
	7	8.9	Rh. s . Di. s . + 6.0
		9.5	Mi. ζ
		15.4	Mi. η
		16.2	En. ζ
		16.8	Rh. ζ
		17.7	Di. ζ
	8	8.1	Mi. ζ
		8.7	En. θ
		9.8	Rh. s . Di. s . - 5.9
		14.0	Mi. η
		15.0	En. ϵ
	9	8.7	Di. Ecl. R.
		10.2	Di. ϵ
		12.7	Mi. η
		17.6	En. θ
		18.1	Mi. θ
		18.4	Te. θ
	10	8.0	Rh. ϵ
		9.1	En. s . Rh. n . + 2.8
		9.8	Di. s . Rh. n . + 3.2
		10.0	En. ζ
		11.3	Mi. η
		11.3	Di. ζ
		12.5	Rh. n . Te. s . + 4.5
		13.5	Di. β
		16.0	Di. Sh.
		16.3	En. η
		16.7	Mi. θ
		16.8	Di. γ
		17.1	Te. ζ
	11	8.8	En. ϵ
		9.9	Mi. η
		15.3	Mi. θ
		15.7	Te. θ
		17.7	Te. δ
	12	8.5	Mi. η
		11.0	Rh. Sh.
		11.3	En. θ
		11.7	Rh. γ
		12.6	En. n . Rh. s . - 1.5
		13.9	Mi. θ

G.M.T. 1892.		h	
May	12	14.2	Rh. η
		14.4	Te. ζ
		16.4	Te. β
		17.7	En. ϵ
		18.3	Te. Sh.
	13	9.6	Di. Sh.
		10.1	En. η
		10.5	Di. γ
		11.6	Te. n . En. s . - 3.1
		12.5	Mi. θ
		12.7	Di. η
		12.9	Te. n . Di. s . - 2.4
		13.0	Te. θ
		15.0	Te. δ
		15.9	Di. s . En. n . - 4.0
		18.4	Te. Ecl. R.
		18.4	Mi. ϵ
		19.8	Titan ζ
		19.9	Te. n . Titan s . + 2.3
		19.9	Te. ϵ
	14	9.3	Titan η
		10.6	Rh. n . Titan s . - 2.7
		11.1	Mi. θ
		11.4	Rh. θ
		11.7	Te. ζ
		12.1	Di. n . Titan s . - 3.3
		12.7	En. ζ
		13.7	Te. β
		13.9	Di. θ
		14.0	Rh. δ
		15.6	Te. Sh.
		16.1	Di. δ
		16.6	Te. γ
		17.1	Mi. ϵ
		18.6	Te. η
		19.0	Rh. Ecl. R.
		19.0	En. η
	15	9.8	Mi. θ
		10.3	Te. θ
		11.4	En. ϵ
		12.3	Te. δ
		15.7	Mi. ϵ
		15.8	Te. Ecl. R.
		17.2	Te. ϵ
	16	9.0	Te. ζ
		9.6	Di. s . En. n . - 4.0
		11.0	Te. β
		12.9	Te. Sh.
		13.9	Te. γ
		14.0	En. θ
		14.3	Mi. ϵ
		14.9	Te. s . En. n . - 1.7
		15.9	Te. η
		17.6	Rh. ζ
	17	8.5	Te. n . En. n . - 1.7
		9.6	Te. δ
		9.8	Di. δ
		12.8	En. η
		12.9	Mi. ϵ

G.M.T. 1892.		h	
May 17	13:1	Te. Ecl. R.	
	13:8	Di. Ecl. R.	
	14:5	Te. ϵ	
	15:2	Di. ϵ	
18	8:3	Te. β	
	10:2	Te. Sh.	
	11:2	Te. γ	
	11:5	Mi. ϵ	
	13:2	Te. η	
	15:3	En. ζ	
	16:4	Di. ζ	
	16:9	Mi. ζ	
	18:6	Di. β	
19	8:8	Rh. ϵ	
	10:1	Mi. ϵ	
	10:4	Te. Ecl. R.	
	11:8	Te. ϵ	
	14:1	En. ϵ	
	15:5	Mi. ζ	
20	7:5	Te. Sh.	
	8:5	Te. γ	
	8:8	Mi. ϵ	
	8:9	Di. ϵ	
	10:5	Te. η	
	13:3	Te. s. En. n. - 3'8	
	14:2	Mi. ζ	
	16:6	En. θ	
21	8:6	Rh. β	
	9:1	En. ζ	
	9:1	Te. ϵ	
	10:0	Di. ζ	
	11:9	Rh. Sh.	
	12:3	Di. β	
	12:5	Rh. γ	
	12:8	Mi. ζ	
	14:7	Di. Sh.	
	15:1	Rh. η	
	15:4	En. η	
	15:6	Di. γ	
	17:8	Di. η	
22	11:4	Mi. ζ	
	11:6	Titan α	
	13:8	Di. n. Te. s. - 4'8	
	15:5	Titan ϵ	
	17:1	En. s. Titan n. + 2'8	
	17:3	Mi. η	
	18:0	En. ζ	
	18:9	Di. θ	
23	10:0	Mi. ζ	
	10:4	En. θ	
	12:3	Rh. θ	
	14:8	Rh. δ	
	15:9	Mi. η	
	16:8	En. ϵ	
24	8:3	Di. Sh.	
	8:6	Mi. ζ	
	9:2	En. η	
	9:3	Di. γ	
	11:5	Di. η	

G.M.T. 1892.		h	
May 24	14:6	Mi. η	
	14:7	Di. s. En. n. - 4'0	
	16:0	Di. s. Te. n. - 4'6	
25	11:7	En. ζ	
	12:6	Di. θ	
	12:9	Rh. n. Te. n. + 4'9	
	13:2	Mi. γ	
	14:2	Di. δ	
	18:1	En. η	
	18:5	Rh. ζ	
	18:6	Mi. θ	
	18:9	Di. Ecl. R.	
26	9:1	Rh. s. Te. s. - 4'9	
	10:5	En. ϵ	
	11:8	Mi. η	
	17:2	Mi. θ	
	18:2	Te. θ	
27	8:4	Di. s. En. n. - 4'0	
	10:4	Mi. η	
	13:1	En. θ	
	15:7	Rh. n. Di. s. - 6'3	
	15:8	Mi. θ	
	16:8	Te. ζ	
28	8:4	Rh. Ecl. R.	
	8:5	Di. δ	
	9:0	Mi. η	
	9:7	Rh. ϵ	
	11:9	En. η	
	12:6	Di. Ecl. R.	
	13:7	Te. n. En. s. - 3'3	
	14:0	Di. ϵ	
	14:4	Mi. θ	
	15:5	Te. θ	
	17:5	Te. δ	
29	11:7	Te. s. En. s. + 3'6	
	13:1	Mi. θ	
	14:1	Te. ζ	
	14:4	En. ζ	
	15:1	Di. ζ	
	16:1	Te. β	
	17:4	Di. β	
	18:1	Te. Sh.	
	18:4	Titan ζ	
30	7:9	Titan η	
	9:5	Rh. β	
	11:0	Te. n. Titan s. - 3'3	
	11:7	Mi. θ	
	12:8	Te. θ	
	12:8	Rh. Sh.	
	13:2	En. ϵ	
	13:4	Rh. γ	
	14:8	Te. δ	
	15:9	Rh. η	
31	7:7	Di. ϵ	
	9:6	Di. n. Te. s. + 3'4	
	10:3	Mi. θ	
	11:5	Te. ζ	
	13:5	Te. β	
	15:4	Te. Sh.	

G.M.T. 1892.		G.M.T. 1892.	
	h		h
May 31	15.7 En. θ	June 6	10.6 Rh. ϵ
	16.2 Mi. ϵ		13.3 Mi. ζ
	16.4 Te. γ		14.1 Rh. n . En. n . + 4.0
June 1	8.2 En. ζ		15.6 Rh. n . Di. s . + 4.7
	8.8 Di. ζ		16.8 Titan n . Te. s . - 4.9
	8.9 Mi. θ	7	9.0 Te. ϵ
	10.1 Te. θ		10.5 Titan α
	11.1 Di. β		11.9 Mi. ζ
	12.1 Te. δ		12.2 En. θ
	13.1 Rh. θ		14.4 Titan ϵ
	13.5 Di. Sh.	8	7.3 Di. δ
	13.9 En. s . Rh. n . - 1.9		7.6 Te. η
	14.3 Di. γ		7.8 Rh. ζ
	14.5 En. η		10.4 Rh. β
	14.8 Mi. ϵ		10.6 Mi. ζ
	15.6 Te. Ecl. R.		11.0 En. η
	15.7 Rh. δ		11.4 Di. Ecl. R.
	16.5 Di. η		12.8 Di. ϵ
	17.0 Te. ϵ		13.8 Rh. Sh.
2	8.8 Te. ζ		14.3 Rh. γ
	10.8 Te. β		16.5 Mi. η
	12.8 Te. Sh.		16.8 Rh. η
	13.4 Mi. ϵ	9	9.2 Mi. ζ
	13.7 Te. γ		9.4 Te. n . En. s . + 4.0
	15.7 Te. η		10.2 Di. s . Te. n . + 4.3
	17.1 En. θ		13.5 En. ζ
	17.7 Di. θ		13.9 Di. ζ
3	7.4 Te. θ		15.1 Mi. η
	9.4 Te. δ		16.2 Di. β
	9.5 En. θ	10	9.5 Rh. n . Te. s . - 4.5
	10.8 Rh. s . Di. n . + 6.1		12.3 En. ϵ
	12.1 Mi. ϵ		13.7 Mi. η
	12.9 Te. Ecl. R.		14.0 Rh. θ
	14.3 Te. ϵ		16.6 Rh. δ
	15.9 En. ϵ	11	12.0 Di. n . Te. s . + 5.0
4	8.0 Di. γ		12.3 Mi. η
	8.1 Te. β		14.9 En. θ
	8.3 En. η	12	9.9 Di. β
	10.1 Te. Sh.		11.0 Mi. η
	10.2 Di. η		12.3 Di. Sh.
	10.8 Mi. ϵ		13.1 Di. γ
	11.0 Te. γ		13.7 En. η
	13.0 Te. η		15.3 Di. η
	13.0 Di. s . En. s . - 4.0	13	9.6 Mi. η
	16.1 Mi. ζ		11.0 Rh. s . Di. n . - 5.0
5	9.3 Mi. ϵ		15.0 Mi. θ
	10.2 Te. Ecl. R.		16.2 En. ζ
	10.9 En. ζ		16.5 Di. θ
	11.2 Te. n . En. s . + 2.2		16.7 Te. ζ
	11.4 Di. θ	14	7.5 Titan s . Di. n . + 5.6
	11.6 Te. ϵ		8.2 Mi. η
	13.6 Di. δ		8.7 En. θ
	14.7 Mi. ζ		13.6 Mi. θ
	17.2 En. η		15.0 En. ϵ
	17.7 Di. Ecl. R.		15.3 Te. θ
6	8.3 Te. γ		15.9 En. n . Titan s . + 2.8
	9.3 Rh. Ecl. R.		17.3 Te. δ
	9.6 En. ϵ		17.4 Titan ζ
	10.3 Te. η	15	8.1 En. s . Titan s . - 2.7

G.M.T. 1892.		h
June 15	9'1	Di. η
	10'2	Rh. Ecl. R.
	11'5	Rh. ϵ
	12'1	Titan s. En. s. -4'0
	12'2	Mi. θ
	12'3	Di. s. En. s. -4'0
	12'9	Te. s. Rh. n. +3'0
	13'0	Di. s. Titan s. -4'3
	14'0	Te. ζ
	16'0	Te. β
16	10'0	En. ζ
	10'2	Di. θ
	10'9	Mi. θ
	12'4	Di. δ
	12'6	Te. θ
	14'6	Te. δ
17	8'8	Rh. ζ
	8'8	En. ϵ } δ +2'3
	9'5	Mi. θ
	10'1	Te. s. En. n. +3'0
	11'3	Te. ζ
	11'3	Rh. β
	13'3	Te. β
	14'7	Rh. Sh.
	15'2	Rh. γ
	15'3	Te. Sh.
	15'4	Mi. ϵ
	16'2	Te. γ
18	10'0	Te. θ
	11'3	En. θ
	12'0	Te. δ
	14'0	Mi. ϵ
	15'5	Te. Ecl. R.
	16'9	Te. ϵ
19	8'6	Te. ζ
	10'1	En. η
	10'2	Di. Ecl. R.
	10'6	Te. β
	11'6	Di. ϵ
	12'5	En. s. Rh. n. -3'5
	12'6	Te. Sh.
	13'5	Te. γ
	15'0	Rh. θ
	15'5	Te. η
20	9'3	Te. δ
	10'5	—13 En. closely followed but not overtaken by Di.
	11'3	Mi. ϵ
	12'7	En. ζ
	12'8	Di. ζ
	12'8	Te. Ecl. R.
	13'4	En. s. Te. n. +1'8
	13'5	Te. n. Di. s. +1'9
	14'2	Te. ϵ
	15'0	Di. β
21	9'9	Mi. ϵ
	10'0	Te. Sh.
	10'8	Te. γ
	11'5	En. ϵ
	12'8	Te. η

G.M.T. 1892.		h
June 21	15'3	Mi. ζ
22	10'1	Te. Ecl. R.
	11'5	Te. ϵ
	13'7	Rh. s. Titan n. -5'7
	14'0	En. θ
23	8'2	Te. γ
	8'7	Di. β
	9'7	Titan α
	10'2	Te. η
	11'2	Di. Sh.
	12'0	Di. γ
	12'5	Mi. ζ
	12'8	En. η
	13'6	Titan ϵ
	14'2	Di. η
24	8'8	Te. ϵ
	11'1	Rh. Ecl. R.
	11'1	Mi. ζ
	12'5	Rh. ϵ
	14'0	En. s. Rh. n. +3'1
	15'3	Di. θ
	15'4	En. ζ
25	9'8	Mi. ζ
	14'1	En. ϵ
26	7'9	Di. η
	8'4	Mi. ζ
	9'7	Rh. ζ
	11'1	Di. s. En. n. -4'0
	12'3	Rh. β
	14'3	Mi. η
	15'7	Rh. Sh.
	16'2	Rh. γ
27	9'1	Di. θ
	9'1	En. ζ
	11'3	Di. δ
	12'9	Mi. η
	15'3	Di. Ecl. R.
	15'5	En. η
	16'8	Di. ϵ
28	11'5	Mi. η
	12'6	Di. s. Te. s +4'9
	15'7	Di. s. En. s +3'4
	16'0	Rh. θ
29	10'2	Mi. η
	10'5	En. θ
	15'6	Mi. θ
	16'8	En. ϵ
30	9'0	Di. Ecl. R.
	9'3	En. η
	9'5	Di. ϵ
	12'9	Di. n. Titan s. +3'6
	14'2	Mi. θ
	16'2	Te. s. Titan s. +2'5
	16'2	Rh. s. Di. n. +5'1
	16'6	Te. ζ
	16'8	Titan ζ
July 1	9'0	Rh. s. Titan s. -3'2
	9'3	Di. n. En. n. +3'6
	11'3	Rh. s. Te. n. -4'3
	11'6	Di. ζ

G.M.T. 1892.	h		G.M.T. 1892.	h	
July 1	11.7	Te. η . Titan s . -4.1	July 8	14.1	Di. Ecl. R.
	11.8	En. ζ		15.6	Di. ϵ
	12.8	Mi. θ	9	9.3	Titan α
	13.8	Di. β		10.0	Te. Ecl. R.
	15.2	Te. θ		11.4	Te. ϵ
	16.3	Di. Sh.		13.2	Titan ϵ
2	13.9	Te. ζ	10	8.1	Te. γ
	15.9	Te. β		8.2	Rh. η
3	12.0	Rh. Ecl. R.		10.1	Te. η
	12.5	Te. θ	11	7.3	Te. Ecl. R.
	13.5	Rh. ϵ		7.8	Di. Ecl. R.
	14.5	Te. δ		8.7	Te. ϵ
4	7.6	Di. β		9.4	Di. ϵ
	10.8	Di. γ	12	7.4	Te. η
	11.2	Te. ζ		8.0	Rh. δ
	13.0	Di. η		10.5	Di. ζ
	13.2	Te. β		12.7	Di. β
5	9.9	Te. θ		12.9	Rh. Ecl. R.
	10.7	Rh. ζ		14.5	Rh. ϵ
	11.9	Te. δ	14	11.7	Rh. ζ
	13.3	Rh. β		14.3	Rh. β
	14.2	Di. θ	15	9.7	Di. γ
	15.3	Te. Ecl. R.		11.9	Di. η
6	8.5	Te. ζ	16	13.1	Di. θ
	10.5	Te. β		15.3	Di. δ
	13.4	Te. γ		16.6	Titan ζ
	15.4	Te. η	17	6.1	Titan η
7	9.2	Te. δ	19	9.3	Rh. η
	12.6	Te. Ecl. R.	21	9.1	Rh. δ
	14.1	Te. ϵ		13.8	Rh. Ecl. R.
	17.0	Rh. θ		15.5	Rh. ϵ
8	7.9	Te. β	23	12.8	Rh. ζ
	7.9	Di. θ		14.4	Rh. β
	10.1	Di. δ	25	9.3	Titan α
	10.8	Te. γ		13.1	Titan ϵ
	12.8	Te. η			

Ephemeris for Physical Observations of Mars, 1892. By A. Marth.

Greenwich Noon.	Angle of Position of β 's Axis.	Areographical Long. Lat. of Centre of Disc.	Apparent Dia- meter.	q	Q	E	Light- ratio.
1892.							
May 1	11.13	78.92 - 12.52	10.80	1.34	259.00	41.27	0.339
3	10.51	59.76 12.82	11.01	1.36	258.67	41.16	0.353
5	9.90	40.61 13.12	11.22	1.38	258.35	41.04	0.369
7	9.29	21.47 13.41	11.44	1.40	258.05	40.90	0.385
9	8.69	2.33 13.68	11.66	1.41	257.76	40.74	0.402
11	8.10	343.21 13.94	11.89	1.43	257.48	40.56	0.420
13	7.51	324.11 14.18	12.13	1.44	257.22	40.36	0.439
15	6.93	305.02 14.42	12.37	1.46	256.98	40.14	0.459
17	6.36	285.94 14.64	12.62	1.47	256.75	39.90	0.480
19	5.81	266.88 - 14.85	12.88	1.48	256.54	39.63	0.502

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Greenwich Noon.	Angle of Position of δ 's Axis.	Areographical Long. Lat. of Centre of Disc.	Apparent Dia- meter.	q	Q	E	Light- ratio.
1892.							
May 21	5°26	247°83 — 15°04	13'15	1'49	256°35	39°34	0'526
23	4°73	228°80 15°22	13'42	1'50	256°17	39°02	0'551
25	4°21	209°80 15°39	13'70	1'50	256°02	38°67	0'577
27	3°70	190°81 15°54	13'99	1'51	255°88	38°30	0'605
29	3°21	171°85 15°68	14'28	1'51	255°77	37°90	0'634
31	2°74	152°91 — 15°80	14'59	1'50	255°68	37°47	0'665
June 2	2°28	134°00 15°91	14°90	1'50	255°61	37°00	0'698
4	1°84	115°12 16°01	15°22	1'49	255°56	36°50	0'733
6	1°42	96°26 16°09	15°55	1'48	255°54	35°97	0'769
8	1°02	77°44 16°15	15°88	1'47	255°55	35°41	0'808
10	0°64	58°64 — 16°20	16°22	1'45	255°59	34°81	0'848
12	0°28	39°88 16°24	16°57	1'43	255°66	33°17	0'891
14	359°94	21°16 16°26	16°93	1'40	255°76	33°49	0'936
16	359°63	2°47 16°26	17°29	1'37	255°90	32°77	0'983
18	359°34	343°82 16°25	17°66	1'34	256°07	32°01	1'032
20	359°08	325°21 — 16°22	18°04	1'30	256°29	31°20	1'084
22	358°84	306°64 16°18	18°42	1'26	256°55	30°34	1'138
24	358°64	288°12 16°12	18°80	1'21	256°86	29°44	1'194
26	358°46	269°65 16°05	19°19	1'16	257°23	28°49	1'253
28	358°32	251°22 15°96	19°58	1'11	257°66	27°50	1'313
30	358°20	232°84 — 15°86	19°97	1'05	258°16	26°45	1'376
July 2	358°11	214°51 15°75	20°36	0'98	258°74	25°35	1'440
4	358°06	196°23 15°62	20°75	0'91	259°41	24°21	1'505
6	358°04	178°00 15°48	21°13	0'84	260°18	23°02	1'572
8	358°05	159°82 15°33	21°51	0'77	261°08	21°77	1'639
10	358°09	141°68 — 15°16	21°88	0'69	262°12	20°48	1'707
12	358°16	123°60 14°99	22°24	0'62	263°34	19°15	1'775
14	358°26	105°57 14°81	22°58	0'54	264°77	17°78	1'841
16	358°40	87°58 14°61	22°91	0'46	266°47	16°37	1'906
18	358°57	69°64 14°41	23°22	0'39	268°53	14°92	1'969
20	358°76	51°74 — 14°21	23°51	0'32	271°06	13°45	2'029
22	358°98	33°88 14°00	23°78	0'26	274°23	11°97	2'085
24	359°23	16°06 13°79	24°02	0'20	278°31	10°49	2'137
26	359°50	358°28 13°58	24°23	0'15	283°72	9°04	2'183
28	359°79	340°52 13°37	24°41	0'11	291°1	7°66	2'223
30	0°10	322°78 — 13°16	24°55	0'08	301°5	6°44	2'256
Aug. 1	0°41	305°05 12°96	24°66	0'06	316°1	5°48	2'282
3	0°74	287°34 — 12°77	24°74	0'05	335°1	4°98	2'300

H H

	Greenwich Noon.	Angle of Position of β 's Axis.	Areographical Long. Lat. of Centre of Disc.	Apparent Dia- meter.	q	Q	E	Light- ratio.
1892.								
Aug. 5		1°07	269°64 — 12°58	24'78	0'05	355°7	5°07	2'310
7		1°40	251°93 12°41	24'78	0'06	13°6	5°74	2'312
9		1°73	234°22 — 12°25	24'74	0'09	26°9	6°88	2'306
11		2°05	216°50 12°11	24'67	0'12	36°3	8°10	2'292
13		2°36	198°76 11°98	24'57	0'17	43°13	9°53	2'271
15		2°66	181°00 11°87	24'43	0'23	48°15	11°02	2'242
17		2°95	163°21 11°79	24'26	0'29	52°00	12°54	2'207
19		3°21	145°39 — 11°72	24°06	0'36	55°04	14°06	2'166
21		3°45	127°54 11°67	23'83	0'44	57°49	15°58	2'119
23		3°67	109°65 11°65	23'57	0'52	59°51	17°07	2'067
25		3°86	91°71 11°65	23'29	0'60	61°21	18°53	2'012
27		4°02	73°73 11°67	23°00	0'69	62°66	19°95	1'954
29		4°14	55°70 — 11°72	22°68	0'78	63°89	21°33	1°893
31		4°23	37°62 11°79	22°35	0'87	64°95	22°66	1°831
Sept. 2		4°29	19°49 11°88	22°01	0'95	65°87	23°95	1°768
4		4°32	1°31 11°99	21°66	1°03	66°67	25°19	1°704
6		4°31	343°08 12°13	21°30	1°11	67°37	26°38	1°640
8		4°27	324°80 — 12°29	20°94	1°19	67°98	27°52	1°577
10		4°20	306°46 12°46	20°57	1°26	68°51	28°61	1°515
12		4°10	288°07 12°66	20°20	1°32	68°97	29°65	1°454
14		3°96	269°64 12°87	19°83	1°38	69°36	30°64	1°394
16		3°80	251°15 13°10	19°45	1°44	69°70	31°58	1°336
18		3°60	232°62 — 13°35	19°08	1°49	69°98	32°48	1°279
20		3°37	214°04 13°61	18°72	1°54	70°22	33°33	1°244
22		3°11	195°41 13°88	18°36	1°58	70°41	34°14	1°172
24		2°83	176°74 14°17	18°00	1°62	70°57	34°90	1°121
26		2°52	158°02 14°47	17°64	1°65	70°69	35°61	1°072
28		2°18	139°26 — 14°78	17°29	1°68	70°77	36°28	1°026
30		1°81	120°45 15°10	16°95	1°70	70°83	36°92	0°981
Oct. 2		1°42	101°60 15°43	16°62	1°72	70°86	37°52	0°938
4		1°01	82°72 15°76	16°29	1°73	70°87	38°08	0°898
6		0°58	63°80 16°10	15°97	1°74	70°85	38°60	0°859
8		0°13	44°84 — 16°45	15°65	1°75	70°82	39°09	0°822
10		359°66	25°85 16°80	15°34	1°76	70°77	39°55	0°787
12		359°16	6°83 17°15	15°04	1°76	70°70	39°98	0°753
14		358°65	347°77 17°51	14°75	1°76	70°61	40°38	0°721
16		358°12	328°68 17°87	14°46	1°75	70°52	40°75	0°690
18		357°58	309°55 — 18°23	14°18	1°75	70°41	41°09	0°661

March 1892.

Observations of Mars, 1892.

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Greenwich Noon.	Angle of Position of $\mathcal{J}$'s Axis.	Areographical Long. Lat. of Centre of Disc.	Apparent Dia- meter.	q	Q	E	Light- ratio.
1892.							
Oct. 20	357°02	290°40 — 18°58	13'91	1"74	70°29	41°41	0.634
22	356°45	271°22 18°94	13'64	1"73	70°16	41°70	0.607
24	355°86	252°01 19°30	13'38	1"72	70°03	41°96	0.582
26	355°25	232°77 19°65	13'13	1"70	69°89	42°20	0.558
28	354°64	213°50 — 20°00	12'88	1"69	69°75	42°42	0.536
30	354°01	194°21 20°34	12'64	1"67	69°60	42°62	0.515
Nov. 1	353°38	174°90 20°68	12'41	1"65	69°45	42°80	0.494
3	352°73	155°56 21°02	12'18	1"63	69°30	42°96	0.475
5	352°07	136°20 21°35	11'96	1"61	69°15	43°10	0.456
7	351°40	106°82 — 21°67	11'74	1"59	68°99	43°22	0.438
9	350°73	97°41 21°98	11'53	1"57	68°84	43°32	0.421
11	350°05	77°98 22°28	11'33	1"55	68°69	43°41	0.405
13	349°37	58°54 22°58	11'13	1"53	68°54	43°48	0.390
15	348°68	39°08 22°87	10'93	1"50	68°39	43°54	0.375
17	347°98	19°60 — 23°14	10'74	1"48	68°24	43°58	0.361
19	347°28	0°10 23°41	10'56	1"46	68°10	43°61	0.348
21	346°57	340°58 23°67	10'38	1"43	67°96	43°63	0.335
23	345°86	321°05 23°91	10'20	1"41	67°82	43°63	0.323
25	345°15	301°50 24°14	10'03	1"38	67°70	43°61	0.312
27	344°44	281°94 — 24°36	9'86	1"36	67°58	43°59	0.301
29	343°72	262°36 24°57	9'70	1"34	67°46	43°55	0.290
Dec. 1	343°00	242°77 24°76	9'54	1"31	67°35	43°51	0.280
3	342°29	223°16 24°94	9'39	1"29	67°24	43°45	0.270
5	341°58	203°54 25°11	9'24	1"26	67°14	43°38	0.261
7	340°87	183°92 — 25°26	9'10	1"24	67°05	43°30	0.252
9	340°16	164°28 25°40	8'95	1"21	66°97	43°21	0.244
11	339°46	144°64 25°53	8'81	1"19	66°89	43°12	0.236
13	338°76	124°98 25°64	8'68	1"17	66°82	43°02	0.228
15	338°07	105°32 25°73	8'55	1"14	66°76	42°90	0.221
17	337°38	85°65 — 25°81	8'42	1"12	66°71	42°78	0.214
19	336°70	65°97 25°87	8'29	1"10	66°66	42°65	0.207
21	336°03	46°28 25°92	8'17	1"07	66°63	42°51	0.200
23	335°36	26°59 25°95	8'05	1"05	66°60	42°36	0.194
25	334°70	6°90 25°96	7'93	1"03	66°59	42°21	0.188
27	334°05	347°20 — 25°96	7'82	1"01	66°58	42°05	0.182
29	333°42	327°50 25°94	7'71	0°98	66°58	41°88	0.177
31	333°79	307°79 — 25°91	7'60	0°96	66°59	41°70	0.172

The differences of successive values of the areographical longitude of the centre of the planet's disc amount, for an interval of two days, to about 19° less than two rotations, so that the greatest difference, at the beginning of August, is $702^\circ.30$, and the smallest, at the end of December, $700^\circ.29$.

Q denotes the position-angle and q the amount of the greatest defect of illumination, E the areocentric angle between Earth and Sun. The last column gives the ratio of the apparent brightness of *Mars* to that at mean opposition, the diminution of brightness due to the defect of illumination being assumed to depend simply on the proportion of the unilluminated portion to the whole of the disc.

The data of the ephemeris are founded upon the same elements as those for the oppositions of 1886, 1888, and 1890, and are to be interpolated directly for the times for which they are required, the equation of light having already been taken into account.

The adopted zero-meridian will apparently pass the centre of the disc at the following Greenwich mean times:—

1892.	h m	1892.	h m	1892.	h m
Apr. 30	18 35.7	May 25	10 17.1	June 19	1 44.7
May 1	19 15.1	26	10 56.1	20	2 22.8
2	19 54.4	27	11 35.1	21	3 2.0
3	20 33.8	28	12 14.0	22	3 39.1
4	21 13.1	29	12 52.9	23	4 17.1
5	21 52.5	30	13 31.8	24	4 55.1
6	22 31.8	31	14 10.7	25	5 33.0
7	23 11.1	June 1	14 49.6	26	6 10.9
8	23 50.4	2	15 28.4	27	6 48.7
10	0 29.7	3	16 7.2	28	7 26.5
11	1 9.0	4	16 45.9	29	8 4.3
12	1 48.2	5	17 24.6	30	8 42.0
13	2 27.5	6	18 3.3	July 1	9 19.6
14	3 6.7	7	18 42.0	2	9 57.1
15	3 45.9	8	19 20.6	3	10 34.6
16	4 25.1	9	19 59.2	4	11 12.1
17	5 4.3	10	20 37.7	5	11 49.5
18	5 43.5	11	21 16.2	6	12 26.9
19	6 22.6	12	21 54.7	7	13 4.2
20	7 1.8	13	22 33.1	8	13 41.5
21	7 40.9	14	23 11.5	9	14 18.7
22	8 20.0	15	23 49.9	10	14 55.8
23	8 59.0	17	0 28.2	11	15 32.9
24	9 38.1	18	1 6.4	12	16 9.9

1892.	h m	1892.	h m	1892.	h m
July 13	16 46.9	Aug. 23	17 7.0	Oct. 3	18 20.2
14	17 23.8	24	17 43.8	4	18 59.0
15	18 0.7	25	18 20.6	5	19 37.9
16	18 37.5	26	18 57.5	6	20 16.8
17	19 14.3	27	19 34.5	7	20 55.8
18	19 51.1	28	20 11.5	8	21 34.8
19	20 27.8	29	20 48.5	9	22 13.8
20	21 4.4	30	21 25.6	10	22 52.8
21	21 41.0	31	22 2.8	11	23 31.9
22	22 17.6	Sept. 1	22 40.0	13	0 11.1
23	22 54.1	2	23 17.3	14	0 50.3
24	23 30.6	3	23 54.6	15	1 29.5
26	0 7.1	5	0 32.0	16	2 8.7
27	0 43.5	6	1 9.4	17	2 48.0
28	1 19.9	7	1 46.9	18	3 27.3
29	1 56.3	8	2 24.5	19	4 6.6
30	2 32.6	9	3 2.1	20	4 46.0
31	3 19.0	10	3 39.8	21	5 25.4
Aug. 1	3 45.3	11	4 17.5	22	6 4.8
2	4 21.7	12	4 55.3	23	6 44.3
3	4 58.0	13	5 33.1	24	7 23.8
4	5 34.3	14	6 11.0	25	8 3.3
5	6 10.6	15	6 48.9	26	8 42.9
6	6 46.9	16	7 26.9	27	9 22.5
7	7 23.2	17	8 4.9	28	10 2.1
8	7 59.5	18	8 43.0	29	10 41.8
9	8 35.8	19	9 21.1	30	11 21.4
10	9 12.1	20	9 59.3	31	12 1.1
11	9 48.5	21	10 37.6	Nov. 1	12 40.8
12	10 24.9	22	11 15.9	2	13 20.6
13	11 1.3	23	11 54.2	3	14 0.4
14	11 37.7	24	12 32.6	4	14 40.2
15	12 14.1	25	13 11.0	5	15 20.0
16	12 50.6	26	13 49.5	6	15 59.8
17	13 27.1	27	14 28.0	7	16 39.7
18	14 3.7	28	15 6.6	8	17 19.6
19	14 40.3	29	15 45.2	9	17 59.5
20	15 16.9	30	16 23.9	10	18 39.4
21	15 53.5	Oct. 1	17 2.6	11	19 19.4
22	16 30.2	2	17 41.4	12	19 59.3

1892.	h	m	1892.	h	m	1892.	h	m
Nov. 13	20	39.3	Nov. 30	7	21.8	Dec. 16	18	7.8
14	21	19.3	Dec. 1	8	2.1	17	18	48.2
15	21	59.4	2	8	42.4	18	19	28.7
16	22	39.4	3	9	22.7	19	20	9.2
17	23	19.5	4	10	3.0	20	20	49.7
18	23	59.6	5	10	43.4	21	21	30.2
20	0	39.7	6	11	23.7	22	22	10.7
21	1	19.8	7	12	4.1	23	22	51.2
22	2	0.0	8	12	44.4	24	23	31.7
23	2	40.2	9	13	24.8	26	0	12.2
24	3	20.4	10	14	5.2	27	0	52.7
25	4	0.6	11	14	45.6	28	1	33.2
26	4	40.8	12	15	26.0	29	2	13.7
27	5	21.0	13	16	6.5	30	2	54.2
28	6	1.2	14	16	46.9	31	3	34.7
29	6	41.5	15	17	27.3			

Col. Cooper's Observatory:
Markree, Collooney, Ireland.

Errata in Mr. Jacoby's Papers.

- Page 109, opposite $\phi = 37^\circ 50'$, column A, for 1 35 57.93 read 1 34 57.93
 „ 110 „ $\phi = 40^\circ 10'$ „ y „ + .0663 read + 0.563
 „ 113 „ $\phi = 54^\circ 20'$ „ y, insert the difference 6
 „ *ib.* „ $\phi = 55^\circ 0'$ „ x (difference), for 74 read 72
 „ 115, line 15, for of the read after
 „ 115, in the equation strike out letter B
 „ 116, equation (a), in first term, for z read x

Erratum in Professor Oudemans' Paper.

At bottom of page 159 (before the note) add the following words:

Accordingly, in my opinion, the dark line seen October 29 and November 3 must be taken for the dusky ring, projected on the planet.